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# Different Capital Investment Measures and Their Associations with Future Stock Returns

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**ABSTRACT**

We examine different measures of capital investment commonly applied in the finance literature and investigate their associations with future stock returns. Investment measures are validated based on their correlations with investment opportunity sets, future realized growth, and contemporary employee turnover. We find that more powerful investment measures are more closely associated with future stock returns. Capital-expenditure-based proxies often underperform investment proxies constructed on simple accounting variables. Research and development responds well to investment opportunities in some industries but appears to be a poor indicator of firm growth in others. We investigate several sources of the differences in performance across various investment measures.

*JEL Classifications:* *G14, G31, M41*

*Keywords:* *capital investment; capital expenditure; stock returns; investment opportunities*

## I. INTRODUCTION

Financial economists have long recognized that capital investment affects firm growth, risk, and size, and thus, can have a significant impact on firm value (e.g., Berk, Green, and Naik, 1999). A number of recent studies in accounting and finance, including Smith and Watts (1992), Gaver and Gaver (1993), Baber, Janakiraman and Kang (1996), Tang and Li (2008), and Fricke and Fung (2009), examine the association between proxies for capital investment, risk, and firm policies on financing, accounting, and compensation. Relying mainly on intuitive arguments, these studies use different ad hoc proxies for capital investment. The wide differences among these investment measures raise a concern that findings in one study with one investment proxy may not be generalized, especially if the researchers' choice is not a valid measure of investment intensity. For example, researchers have documented different relationships between capital investment and future stock returns using different investment proxies (Titman, Wei, and Xie, 2004; Lev and Thiagarajan, 1993). To date, little research has been done to validate these capital investment measures. Capital investment reacts to investment opportunities, leads to firm growth, and is accompanied by firm structural changes, such as employee turnover. We thus evaluate various proxies for capital investment with these benchmark variables and examine their associations with future stock returns.

Our empirical tests confirm that most investment variables applied in the literature, except capital expenditure scaled by firm value, are valid proxies. However, significant differences exist in the performance of these measures. Investment variables constructed on simple accounting statistics such as growth of property, plant, and equipment (PPE) or growth of long-term assets often perform as well as or even better than more commonly applied investment proxies, i.e., capital expenditure scaled by various deflators. These accounting statistics may capture capital investment more comprehensively as they incorporate effects from firm divestment, investment by acquisition, and non-cash investment. Among variables that are based on capital expenditure, we find that the choice of deflators can significantly affect the performance of these proxies. For example, capital expenditure deflated by PPE generally performs best while capital expenditure deflated by the market value of firm assets appears problematic. Research and development (R&D) responds well to investment opportunities in some industries, such as hi-tech, healthcare, and telecom,but appears to be a poor indicator of firm growth in other industries, such as wholesale, retail, and consumer non-durables. We investigate possible sources for the differences in the performance of these variables and obtain preliminary evidence supporting our explanations. Overall, all better-performing proxies are consistent with the spirit of the Hayashi (1982) model. Moreover, better-performing proxies generally have stronger associations with future stock returns. For instance, out of the four investment measures in Titman et al., there appears to be a monotonic relationship between validation performance and investment-based hedge returns. Thus, refining investment proxies could potentially help investors improve trading profits.

The contribution of this paper is several-fold. First, our results should aid researchers in constructing appropriate investment proxies. More powerful measures may enhance the significance of researchers' findings. Measurement errors in weak investment proxies may bias estimated coefficients when those variables are used as independent variables in regressions (e.g., Kang, Kumar and Lee, 2006; Aivazian, Ge, and Qiu, 2005). Second, our results may help to interpret several findings in previous studies that are not robust to the choice of the capital investment proxy. For example, we find that capital expenditure deflated by market value may not be a valid measure of investment. Hence, findings in studies that applied such measures may need to be interpreted with caution (e.g., Smith and Watts, 1992; Vogt, 1997). In another example, Titman, Wei and Xie (2004) find that abnormal investment is negatively correlated with abnormal future stock returns, whereas Lev and Thiagarajan (1993) find that R&D is positively correlated with abnormal future stock returns. We find that the investment variables applied in the two studies differ dramatically in their correlations with profitability-driven investment opportunities. Thus, the contradictory findings in the two studies could be attributable to the choice of investment measurement. Third, our research should interest fundamental analysts as they quest for powerful predictors of stock returns. Lastly, we analyze the performances of various investment proxies within each industry. The results may aid researchers in constructing powerful investment measures for firms in certain industries.

The organization of the paper is as follows: In the next section, we discuss the grounds for our validation approaches and introduce several widely applied investment measures. Section III describes our sample. Section IV reports empirical results, and we conclude in Section V.

## II. INVESTMENT MEASURES AND BENCHMARK VARIABLES

We first provide a link that relates investment with investment opportunities. An investment proxy that best reflects investment opportunities may be considered more accurate. In a seminal study, Hayashi (1982) shows that under certain conditions, the following equation holds: [1]

$$\frac{I}{K} = a + \frac{1}{\alpha}[Q - 1] + \lambda \tag{1}$$

where I is firm investment, K is the beginning-of-period capital stock, $\alpha$ is a parameter linearly increasing in the cost of adjustment function, Q is the present value of profits from new capital investment and represents investment opportunity, and $\lambda$ is technology shock.

Based on the Hayashi model, two conclusions could be drawn. First, capital investment should be linearly associated with investment opportunity. We thus validate investment measures by their associations with proxies of investment opportunity. Second, a good measure of investment should be deflated by the beginning-of-period capital stock K, either PPE (property, plant and equipment) or long-term assets. Such deflators may work better than other arbitrary variables, such as sales or expenditures in previous years. This prediction is confirmed by our empirical results.

We apply the following variables to proxy for investment opportunities: Tobin’s Q, profitability (Blanchard, Rhee and Summers, 1993), past sales growth (Shin and Stulz, 1996), and value of growth opportunity (Richardson, 2006). [2]

Second, we choose a benchmark for ex post realization of investment. Investment leads to future growth in sales, earnings, and book values. Following a similar approach to Kallpur and Trombley (1999) and Richardson (2002), we focus on ex post realized sales growth, and examine its correlation with various investment proxies.[3]

Third, we link a firm's capital investment with investment in human capital. In general, a firm would respond to investment opportunities with contemporaneous increases in both physical and human capital. Capital investment is often accompanied by firm structural changes, such as employee turnover. We, thus, validate investment measures by examining concurrent employee changes.

Lastly, a firm's investment depends not only on firm-specific factors but also on industry-specific factors. Therefore, we also examine how various investment proxies perform after industry adjustment.

We first identify the candidate investment proxies to be included in our empirical tests from a list of representative studies in the finance and accounting literature:

1. Capital expenditure/PPE (e.g., Aggarwal and Samwick, 2006)
2. Capital expenditure/Total Assets (e.g., Blanchard, Lopez-de-Silanes and Shleifer, 1994)
3. Capital expenditure/Sales (e.g., Anderson and Garcia-Feijoo, 2006; Titman et al., 2004)
4. Capital expenditure/Value (e.g., Smith and Watts, 1992; Vogt, 1997).
5. R&D/Total Assets (e.g., Gaver and Gaver, 1993)
6. Growth in inventory (e.g., Kashyap, Lamont and Stein, 1994)
7. Growth in capital expenditure (e.g., Lev and Thiagarajan, 1993; Callen et al., 1996)
8. Sum of capital expenditure on PPE, acquisitions, and research and development deflated by depreciation expense (e.g., Baber et al., 1996)
9. Change in long-term assets deflated by average total assets (e.g., Hsiao and Li, 2011)

In addition, we construct several proxies that are not as widely applied in the literature but may nonetheless capture Hayashi's idea of investment:

10. Growth in PPE, either net PPE or gross PPE[4]
11. Growth in long-term assets
12. Cash flows in investing activities: -(-increase in investment + sale of investment-capital expenditure + Sale of PPE-acquisition), deflated by average total assets[5]
13. Lastly, we add the four investment measures in Titman et al. (2004)[6]

Ex ante, we may predict the relative performance among several of the investment measures. For example, capital expenditure/sales probably would be a noisier measure than capital expenditure/PPE. This is because the former measure could be decomposed as the product of the latter measure and the ratio of sales/PPE. It is well-known that the sales turnover ratio (sales/PPE) varies significantly across industries, and thus, introduces some noise into the investment proxy. Another issue concerns capital expenditure. Note that it is always non-negative and omits retirement of any PPE. Focusing on only capital expenditure ignores divestment from the sale of PPE and investment through acquisition, e.g., where firms liquidate one investment item to finance another investment project. Such transactions represent potential omitted variables and potentially create an errors-in-variables problem in prior research.

Also, using growth of capital expenditure may be problematic if there is little capital expenditure in a prior year. An intuitive measure might simply be constructed as the change in PPE scaled by lagged PPE, or the change in long-term assets scaled by lagged long-term assets. After all, this is what the Hayashi model purports to capture.

## III. SAMPLE AND VARIABLE DESCRIPTION

In this section, we describe our selected investment measures. A more accurate measure of investment should be more closely related to investment opportunities, firm growth, and employee turnover. Our sample consists of all firms for which financial statement information is available on Compustat annual files from 1971 to 2008 and stock return information is available on CRSP. The data begin in the year 1971, because before that year, several variables do not have an adequate number of observations. Financial institutions (SIC codes 6000-6999) are excluded because their investing, operating, and financing activities are not clearly demarcated. The resulting sample covers 120,088 firm years, with a minimum annual sample of 1,740 firms and a maximum annual sample of 4,226 firms.

We generally follow previous studies in constructing capital investment proxies and other variables. The variables are defined in Table 1. The ex ante investment opportunities are proxied by (i) Q, (ii) value of growth opportunities (VGO), as constructed in Richardson (2006), (iii) profitability (ROA), and (iv) past sales growth (SGRO-3), all measured in the year before investment. We consider several measures of investment opportunity due to the concern that Q is a noisy measure. It is well-known that the Q measure suffers from a serious measurement error problem. Researchers have contended that investment chases profitability and higher profitability (ROA) can signal greater project quality or investment opportunities (Biddle, Chen, and Zhang, 2001; Fazzari, Hubbard, and Petersen, 1988; Cleary, 1999; Alti, 2003). We also follow earlier studies (Kaplan and Zingales, 1997) and include growth in sales in the past three years (SGRO-3). Finally, replacing Q with Richardson 2006's measure of growth opportunities (VGO) may provide another sensitivity test. We include these proxies for investment opportunities at the beginning of the year. The ex post measure is growth in sales over the three-year period from year t-1 to t+2 (SGRO+3). Finally, investment is often accompanied by employee turnover, measured as the growth in number of employees during the period of investment (EMPGRO).

Table 2 reports descriptive statistics on a pooled basis for investment measures and various measures of investment opportunity, future realization, and contemporaneous employee growth. In Panel A, the median firm has a PPE growth (PPEGRO) of 0.068, a Q ratio of 1.344, a Vgo of 0.335, an ROA of 0.088, a past three-year sales growth of 36.8%, a future three-year sales growth of 32.0%, and an employee growth of 3.4%. There is considerable variation among all measures of investment. In addition, the lower quartiles of several investment measures (CAPXGRO, DLA/A, INVTGRO, LAGRO, PPEGRO, and EMPGRO) are negative, suggesting that some companies reduce investment or divest in some years. In addition, the lower quartiles of VGO and ROA are negative, indicating negative investment opportunities for some firm-years. Note that the capital expenditure-based proxies (except CAPXGRO) are, by construction, non-negative, so they may not be able to capture reduction in investment associated with negative investment opportunities.

**Table 1**
Variable definitions

| Variable Name | Coding in Table 6 | Description |
|---|---|---|
| | | ***Panel A: Investment Measures*** |
| BABER | 1 | As defined in BABER et al. 1994, defined as the sum of capital expenditure on PPE (data30), acquisition (data129), research and development (data46) , deflated by depreciation expense (data14) |
| CAPX/A | 2 | Capital expenditure (data128) / beginning-of-year total assets (data6) |
| CAPX/PPE | 3 | Capital expenditure (data128) / beginning-of-year net PPE (data8). |
| CAPX/S | 4 | Capital expenditure (data128) / sales (data12) in the previous year |
| CAPX/V | 5 | Capital expenditure (data128) / beginning-of-year firm value (data25*data199+data181) |
| CAPX/V1 | | Capital expenditure (data128) / end-of-year firm value (data25*data199+data181) |
| CAPXGRO | 6 | Growth in capital expenditure, defined as data128 in year t / data128 in year t-1 -1 |
| CFI/A | 7 | Cash flow in investing activities, defined as -(-data113 +data109-data128+data107-data129) or -(-increase in investment + sale of investment-capital expenditure + Sale of PPE-acquisition), divided by beginning-of-year total assets (data6) |
| DLA/A | 8 | Change in long-term asset (data6-data4), deflated by beginning-of-year total assets (data6) |
| INVTGRO | 9 | Growth in inventory, defined as data3 at the end of fiscal year t over its beginning balance -1 |
| LAGRO | 10 | Growth in long-term asset, defined as (data6-data4) at the end of fiscal year t over its beginning balance -1 |
| PPEGRO | 11 | Growth in net PPE, defined as data8 at the end of fiscal year t over its beginning balance -1 |
| PPEGGRO | 12 | Growth in gross PPE, defined as data7 at the end of fiscal year t over its beginning balance -1 |
| R&D/A | 13 | R&D expenditure (data46) over beginning-of-year total assets (data6) |
| TWX1 | 14 | Capital expenditure (data128) / sales (data12), divided by the previous three years' average of this ratio, - 1 |
| TWX2 | 15 | Capital expenditure (data128) / sales (data12), minus the previous three years' average of this ratio |
| TWX3 | 16 | Capital expenditure (data128) / sales (data12) |
| TWX4 | 17 | Capital expenditure (data128), divided by the previous three years' average capital expenditure, - 1 |
| | | ***Panel B: Investment Opportunity Measures*** |
| Q | | Tobin's Q, measured as market value of the firm (data6-data60+data25*data199)/ total assets (data6), at the beginning of year t |
| ROA | | Return on total assets, operating income (data178)/ total assets (data6), in year t-1 |
| $SGRO_{-3}$ | | Sale (data12) in year t-1/ sale in year t-4 -1 |
| VGO | | Value of growth measure as defined in Richardson (2006),(data25*data199-((1-1.24*0.12)*data60+1.24*1.12*data178-1.24*0.12*data21))/average of total asset (data6), in year t-1 |
| | | ***Panel C: Investment Realization Measures*** |
| $SGRO_{+3}$ | | Sale (data12) in year t+2 / sale in year t-1 -1 |

| | ***Panel D: Contemporaneous Measures*** |
|---|---|
| EMPGRO | Growth in number of employees, defined as data29 at the end of fiscal year t over its beginning balance -1 |

Panel B reports correlations among different measures of investment. Given that they all purport to measure the same underlying activities, it is not surprising to see strong positive correlations. However, R&D (R&D/A) is negatively correlated with capital expenditure deflated by firm assets (CAPX/A), capital expenditure deflated by firm value (CAPX/V), investment cash flows (CFI/A), and two measures in Titman et al. Its low or negative association with other investment proxies suggests that it may not gauge the same concept of investment as other variables. In fact, because outcomes from R&D investment are inherently uncertain, accounting standards typically mandate recording R&D as an expense and not as an asset.

It is also interesting to note that growth in PPE (PPEGRO, PPEGGRO), growth in long-term assets (LAGRO), and capital expenditure/PPE (CAPX/PPE) are closely correlated among themselves. For example, the Spearman correlation between CAPX/PPE and PPEGRO is 0.733. This is important, as later it can be shown that these variables are the most powerful proxies amongst all measures.

Panel C of Table 2 reports the correlations between four measures of investment opportunities, future sales growth, and employee turnover. These variables generally have significant positive correlations because they relate to a similar construct. However, except for the correlation between VGO and Q, no correlation exceeds 0.5. Therefore, these variables may validate our investment proxies from different dimensions. VGO is negatively correlated with ROA because of the way VGO is constructed.[7] The high correlation between VGO and Q (0.966) suggests that validation results by these two benchmarks should not be interpreted as independent findings.

## IV. EMPIRICAL RESULTS

### A. Validation Tests

We back-test the correlation between investment proxies and benchmark variables that represent investment opportunities, future sales growth, or employee turnover. This approach faces the problem of using ex post data to measure ex ante constructs. To help mitigate this problem, we use a portfolio approach following Richardson (2002) and Kallapur and Trombley (1999). The assumption is that ex post shocks affecting future realization, employee turnover, or investment opportunities and shocks affected by past capital investment within each portfolio will be uncorrelated. Each year, we sort firms into 50 portfolios on a validation benchmark variable. For the example of future sales growth ($SGRO_{+3}$), for each year, firms are ranked based on realized sales growth over three succeeding years ($SGRO_{+3}$); the 2% of firms with highest sales growth are placed in portfolio 1, the next highest 2% firms are distributed to portfolio 2, and so on. We then compute the Spearman rank correlations between portfolio medians of the benchmark variable and portfolio medians of investment proxies. This procedure is repeated for each year. The reported correlations in Panel A of Table 3 are means of rank correlations over the sample period. Significance for the mean correlation is assessed.

**Table 2**

Descriptive statistics of capital investment and validation benchmark variables

Panel A: Summary statistics

| Variable | N | Mean | Std. Dev | 25 Percentile | Median | 75 Percentile |
|---|---|---|---|---|---|---|
| BABER | 102,411 | 4.124 | 5.587 | 1.337 | 2.421 | 4.493 |
| CAPXGRO | 118,942 | 0.511 | 1.681 | -0.272 | 0.097 | 0.630 |
| CAPX/A | 120,088 | 0.085 | 0.100 | 0.026 | 0.054 | 0.103 |
| CAPX/PPE | 119,841 | 0.381 | 0.481 | 0.134 | 0.236 | 0.424 |
| CAPX/S | 119,971 | 0.154 | 0.433 | 0.022 | 0.045 | 0.100 |
| CAPX/V | 120,088 | 0.058 | 0.067 | 0.016 | 0.037 | 0.074 |
| CAPX/V1 | 119,983 | 0.053 | 0.056 | 0.016 | 0.035 | 0.069 |
| CFI/A | 80,746 | 0.056 | 0.253 | 0.015 | 0.050 | 0.114 |
| DLA/A | 117,275 | 0.080 | 0.224 | -0.012 | 0.027 | 0.100 |
| INVTGRO | 102,788 | 0.179 | 0.563 | -0.067 | 0.082 | 0.272 |
| LAGRO | 117,225 | 0.270 | 0.800 | -0.034 | 0.073 | 0.269 |
| PPEGRO | 119,725 | 0.212 | 0.606 | -0.040 | 0.068 | 0.251 |
| PPEGGRO | 119,326 | 0.205 | 0.435 | 0.029 | 0.100 | 0.235 |
| R&D/A | 57,588 | 0.097 | 0.134 | 0.018 | 0.049 | 0.121 |
| TWX1 | 108,339 | 0.098 | 0.944 | -0.421 | -0.100 | 0.291 |
| TWX2 | 108,540 | -0.023 | 0.177 | -0.021 | -0.003 | 0.010 |
| TWX3 | 119,949 | 0.114 | 0.269 | 0.020 | 0.041 | 0.085 |
| TWX4 | 109,929 | 0.453 | 1.385 | -0.314 | 0.119 | 0.708 |
| Q | 120,082 | 1.944 | 1.781 | 0.999 | 1.344 | 2.097 |
| VGO | 119,992 | 1.086 | 2.198 | -0.024 | 0.335 | 1.168 |
| ROA | 120,088 | 0.053 | 0.195 | 0.016 | 0.088 | 0.151 |
| $SGRO_{-3}$ | 103,257 | 0.988 | 2.774 | 0.082 | 0.368 | 0.839 |
| $SGRO_{+3}$ | 102,845 | 0.721 | 1.825 | 0.030 | 0.320 | 0.739 |
| EMPGRO | 116,323 | 0.102 | 0.354 | -0.048 | 0.034 | 0.161 |

Panel B: Spearman correlations across measures of investments

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BABER | 1.000 | | | | | | | | | | | | | | | |
| CAPXGRO | 0.341 | 1.000 | | | | | | | | | | | | | | |
| CAPX/A | 0.303 | 0.425 | 1.000 | | | | | | | | | | | | | |
| CAPX/PPE | 0.541 | 0.579 | 0.572 | 1.000 | | | | | | | | | | | | |
| CAPX/S | 0.387 | 0.351 | 0.785 | 0.477 | 1.000 | | | | | | | | | | | |
| CAPX/V | 0.097 | 0.321 | 0.843 | 0.337 | 0.598 | 1.000 | | | | | | | | | | |
| CFI/A | 0.345 | 0.360 | 0.728 | 0.450 | 0.531 | 0.610 | 1.000 | | | | | | | | | |
| DLA/A | 0.511 | 0.431 | 0.554 | 0.542 | 0.455 | 0.373 | 0.605 | 1.000 | | | | | | | | |
| INVTGRO | 0.295 | 0.280 | 0.264 | 0.322 | 0.234 | 0.145 | 0.304 | 0.403 | 1.000 | | | | | | | |
| LAGRO | 0.530 | 0.457 | 0.493 | 0.598 | 0.401 | 0.301 | 0.547 | 0.955 | 0.411 | 1.000 | | | | | | |
| PPEGRO | 0.533 | 0.576 | 0.577 | 0.733 | 0.485 | 0.386 | 0.566 | 0.759 | 0.443 | 0.787 | 1.000 | | | | | |
| PPEGGRO | 0.515 | 0.475 | 0.516 | 0.714 | 0.465 | 0.299 | 0.525 | 0.699 | 0.441 | 0.725 | 0.888 | 1.000 | | | | |
| R&D/A | 0.612 | 0.047 | -0.044 | 0.323 | 0.185 | -0.323 | -0.089 | 0.043 | 0.098 | 0.102 | 0.076 | 0.202 | 1.000 | | | |
| TWX1 | 0.340 | 0.662 | 0.468 | 0.588 | 0.349 | 0.403 | 0.372 | 0.391 | 0.143 | 0.408 | 0.539 | 0.400 | -0.056 | 1.000 | | |
| TWX2 | 0.291 | 0.590 | 0.355 | 0.508 | 0.216 | 0.304 | 0.297 | 0.348 | 0.120 | 0.361 | 0.463 | 0.338 | -0.069 | 0.922 | 1.000 | |
| TWX3 | 0.348 | 0.296 | 0.762 | 0.424 | 0.962 | 0.600 | 0.491 | 0.384 | 0.139 | 0.326 | 0.406 | 0.380 | 0.161 | 0.375 | 0.239 | 1.000 |
| TWX4 | 0.443 | 0.753 | 0.570 | 0.743 | 0.471 | 0.420 | 0.480 | 0.560 | 0.322 | 0.584 | 0.732 | 0.626 | 0.032 | 0.841 | 0.748 | 0.411 |

Panel C: Correlations across measures of investment opportunities, sales growth, and employee turnover

| | Q | VGO | ROA | $SGRO_{-3}$ | $SGRO_{+3}$ | EMPGRO |
|---|---|---|---|---|---|---|
| | 1.000 | | | | | |
| VGO | 0.966 | 1.000 | | | | |
| ROA | 0.141 | -0.026 | 1.000 | | | |
| $SGRO_{-3}$ | 0.256 | 0.208 | 0.286 | 1.000 | | |
| $SGRO_{+3}$ | 0.219 | 0.214 | 0.071 | 0.163 | 1.000 | |
| EMPGRO | 0.285 | 0.264 | 0.156 | 0.198 | 0.492 | 1.000 |

All correlations are significant at 0.0001 levels.

using t-statistics. The Newey-West (1987) correction with three lags is applied to t-statistics for correlations related to past and future sales growth.

As expected, most reported correlations are positive and significant. One noticeable exception is from capital expenditure deflated by end-of-year firm market value (CAPX/V1). It is negatively correlated with Q, VGO, and future sales growth and is insignificantly correlated with employee turnover. The negative correlations could be attributable to the use of market value of firm in the denominator, causing the ratio of CAPX/V1 to behave more like a book-to-market measure (or inverse of Q). Overall, end-of-year firm market value may not be a good deflator because it may reflect valuation implications of capital investment, nullifying any information contained in the numerator (capital expenditure). With a beginning-of-year defalcator (CAPX/V), the performance is slightly better, though its correlations with Q and VGO are still negative.[8] In contrast, capital expenditure with other deflators always has significant positive correlations with various benchmark variables.

Consistent with our prediction, PPE (or Long-term assets) generally performs better than total assets or sales as a deflator. CAPX/PPE has correlations of 0.938, 0.882, 0.532, 0.877, 0.868, and 0.945 with Q, VGO, ROA, past sales growth, future sales growth, and employee turnover whereas CAPX/S (CAPX/A) has correlations of 0.884(0.809), 0.869(0.723), 0.208(0.802), 0.718(0.694), 0.843(0.829), and 0.877(0.882).[9]

Among the investment proxies, CAPX/PPE, PPEGGRO (PPEGRO) and LAGRO generally perform better than other proxies. For example, PPEGGRO has a very high correlation of 0.942(0.978) with Q (EMPGRO). Baber's construct has high correlations with Q and VGO, but its correlation with other benchmark variables are not as high. Interestingly, some investment proxies widely used in the literature do not appear to be the most powerful. Capital expenditure-based proxies that are not deflated by PPE generally underperform PPEGGRO, PPEGRO, LAGRO, or DLA/A. The inferior performance of these proxies relative to proxies constructed from growth of long-term assets or PPE may stem from the difference between changes in long-term assets (or PPE) and capital expenditures. For example, CAPX/A always underperforms DLA/A; CAPX/PPE always underperforms PPEGGRO. One explanation for the under-performance of capital expenditure is that it excludes information from divestment, investment by acquisition, and non-cash investment. To investigate this possibility, we construct a new variable that captures the difference between changes in long-term assets and capital expenditures, (DLA-CAPX)/A. The performance of this variable is reported in the last row in Table 3. The correlations of this variable with all benchmark variables are significantly positive, consistent with our intuition.

**Table 3**

Mean annual portfolio Spearman correlations between investment measures and benchmark variables

Each year, we rank an investment measure into 50 portfolios based on its annual distribution. Firms ranked in the top 2% of firms are placed in portfolio 1, the next highest 2% firms go in portfolio 2, and so on. We then compute the Spearman rank correlations between portfolio medians of the benchmark variables and portfolio medians of investment measures. This procedure is repeated for each year. The reported correlations are means of rank correlations in 38 annual portfolios. Validation score (Valid. Score) is the sum of investment measures' correlations with Q, VGO, ROA, $SGRO_{-3}$, $SGRO_{+3}$, and EMPGR. Significance for the mean correlation over the sample period is assessed using t-statistics. The Newey-West (1987) correction with three lags is applied to t-statistics for correlations related to past and future sales growth. In Panel B, investment measures are adjusted by industry median values.

| | Q | VGO | ROA | $SGRO_{-3}$ | $SGRO_{+3}$ | EMP GRO | Valid. Score | Q | VGO | ROA | $SGRO_{-3}$ | $SGRO_{+3}$ | EMP GRO | Valid. Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Panel A Original investment measures | | | | | | | Panel B Industry adjusted investment measures | | | | | | |
| BABER | 0.937 | 0.908 | 0.354 | 0.735 | 0.781 | 0.889 | 4.604 | 0.917 | 0.879 | 0.437 | 0.715 | 0.823 | 0.921 | 4.692 |
| | (197.18) | ( 42.55) | ( 2.86) | ( 16.05) | ( 20.93) | ( 55.46) | | (142.10) | ( 34.60) | ( 3.87) | ( 19.40) | ( 32.10) | ( 99.58) | |
| CAPXGRO | 0.635 | 0.510 | 0.610 | 0.254 | 0.849 | 0.928 | 3.786 | 0.646 | 0.536 | 0.596 | 0.212 | 0.842 | 0.918 | 3.750 |
| | ( 15.00) | ( 8.64) | ( 15.32) | ( 5.42) | ( 35.17) | ( 76.17) | | ( 14.29) | ( 7.90) | ( 12.60) | ( 4.10) | ( 30.71) | ( 68.15) | |
| CAPX/A | 0.809 | 0.723 | 0.802 | 0.694 | 0.829 | 0.882 | 4.739 | 0.886 | 0.827 | 0.791 | 0.697 | 0.849 | 0.917 | 4.967 |
| | ( 20.30) | ( 14.35) | ( 30.49) | ( 13.49) | ( 27.89) | ( 59.88) | | ( 95.37) | ( 52.21) | ( 25.66) | ( 17.74) | ( 44.61) | (103.89) | |
| CAPX/PPE | 0.938 | 0.882 | 0.532 | 0.877 | 0.868 | 0.945 | 5.042 | 0.939 | 0.893 | 0.667 | 0.880 | 0.903 | 0.953 | 5.235 |
| | (158.85) | ( 25.93) | ( 5.46) | ( 62.65) | ( 42.37) | (146.55) | | (136.56) | ( 28.94) | ( 10.34) | ( 86.12) | ( 46.43) | (121.11) | |
| CAPX/S | 0.884 | 0.869 | 0.208 | 0.718 | 0.843 | 0.877 | 4.399 | 0.885 | 0.870 | 0.256 | 0.703 | 0.887 | 0.911 | 4.512 |
| | ( 65.26) | ( 57.52) | ( 2.36) | ( 19.39) | ( 39.17) | ( 50.37) | | ( 80.84) | ( 51.17) | ( 2.55) | ( 21.82) | ( 56.74) | ( 68.73) | |
| CAPX/V | -0.610 | -0.741 | 0.335 | 0.164 | 0.293 | 0.455 | -0.104 | -0.684 | -0.801 | 0.359 | 0.201 | 0.426 | 0.634 | 0.135 |
| | ( -7.69) | (-14.58) | ( 6.41) | ( 1.88) | ( 3.52) | ( 6.81) | | (-13.80) | (-35.87) | ( 6.91) | ( 3.42) | ( 8.43) | ( 17.82) | |
| CAPX/V1 | -0.600 | -0.719 | 0.249 | 0.131 | -0.177 | -0.076 | -1.192 | -0.648 | -0.748 | 0.255 | 0.175 | -0.165 | 0.045 | -1.086 |
| | ( -7.50) | (-12.41) | ( 4.89) | ( 1.63) | ( -1.90) | ( -0.98) | | (-10.63) | (-20.56) | ( 5.45) | ( 3.24) | ( -2.05) | ( 0.61) | |
| CFI/A | 0.622 | 0.479 | 0.811 | 0.643 | 0.786 | 0.893 | 4.234 | 0.746 | 0.642 | 0.781 | 0.656 | 0.802 | 0.902 | 4.529 |
| | ( 8.44) | ( 5.76) | ( 52.24) | ( 16.59) | ( 21.07) | ( 49.98) | | ( 31.60) | ( 19.72) | ( 30.07) | ( 20.75) | ( 24.16) | ( 62.41) | |
| DLA/A | 0.900 | 0.848 | 0.807 | 0.837 | 0.930 | 0.962 | 5.284 | 0.910 | 0.860 | 0.823 | 0.822 | 0.931 | 0.966 | 5.312 |
| | ( 57.97) | ( 40.11) | ( 26.18) | ( 35.02) | ( 71.35) | (147.31) | | (136.63) | ( 38.99) | ( 29.58) | ( 34.49) | ( 65.95) | (179.76) | |
| INVTGRO | 0.832 | 0.768 | 0.648 | 0.719 | 0.940 | 0.975 | 4.882 | 0.827 | 0.760 | 0.691 | 0.707 | 0.932 | 0.973 | 4.890 |
| | ( 51.11) | ( 23.42) | ( 16.27) | ( 23.99) | ( 57.74) | (264.53) | | ( 46.67) | ( 22.55) | ( 19.61) | ( 24.26) | ( 46.33) | (267.08) | |
| LAGRO | 0.934 | 0.871 | 0.777 | 0.860 | 0.937 | 0.971 | 5.350 | 0.934 | 0.879 | 0.810 | 0.849 | 0.942 | 0.972 | 5.386 |
| | (131.57) | ( 31.42) | ( 17.54) | ( 36.40) | ( 70.85) | (199.67) | | (158.71) | ( 31.28) | ( 23.37) | ( 33.92) | ( 67.76) | (181.21) | |
| PPEGRO | 0.927 | 0.848 | 0.790 | 0.885 | 0.936 | 0.978 | 5.364 | 0.928 | 0.869 | 0.814 | 0.869 | 0.940 | 0.974 | 5.394 |
| | (121.96) | ( 30.05) | ( 18.56) | ( 44.04) | ( 63.64) | (264.48) | | (133.35) | ( 28.13) | ( 22.76) | ( 37.78) | ( 61.10) | (190.50) | |
| PPEGGRO | 0.942 | 0.884 | 0.654 | 0.937 | 0.942 | 0.978 | 5.337 | 0.939 | 0.900 | 0.730 | 0.934 | 0.951 | 0.977 | 5.431 |
| | (137.62) | ( 36.35) | ( 9.47) | (134.85) | ( 72.00) | (358.59) | | (131.15) | ( 35.20) | ( 14.51) | (128.06) | ( 64.79) | (260.95) | |
| R&D/A | 0.781 | 0.860 | -0.105 | 0.458 | 0.548 | 0.576 | 3.118 | 0.776 | 0.792 | -0.117 | 0.350 | 0.529 | 0.574 | 2.904 |
| | ( 28.10) | ( 30.02) | ( -0.82) | ( 7.20) | ( 10.40) | ( 13.32) | | ( 30.03) | ( 24.54) | ( -0.77) | ( 4.58) | ( 9.41) | ( 10.92) | |
| TWX1 | 0.397 | 0.158 | 0.828 | -0.099 | 0.091 | 0.657 | 2.032 | 0.433 | 0.183 | 0.813 | -0.176 | 0.106 | 0.651 | 2.010 |
| | ( 8.54) | ( 2.38) | ( 50.20) | ( -2.21) | ( 2.89) | ( 21.56) | | ( 10.91) | ( 3.20) | ( 36.13) | ( -4.53) | ( 2.55) | ( 21.93) | |
| TWX2 | 0.254 | 0.007 | 0.814 | -0.204 | 0.001 | 0.592 | 1.464 | 0.320 | 0.077 | 0.796 | -0.279 | 0.012 | 0.595 | 1.521 |
| | ( 4.74) | ( 0.09) | ( 43.38) | ( -4.18) | ( 0.01) | ( 15.06) | | ( 8.79) | ( 1.38) | ( 33.79) | ( -5.59) | ( 0.23) | ( 14.54) | |
| TWX3 | 0.843 | 0.826 | 0.179 | 0.675 | 0.666 | 0.749 | 3.938 | 0.841 | 0.824 | 0.250 | 0.649 | 0.715 | 0.817 | 4.096 |
| | ( 47.95) | ( 39.18) | ( 1.99) | ( 15.14) | ( 18.50) | ( 38.02) | | ( 62.28) | ( 44.92) | ( 2.70) | ( 17.76) | ( 22.85) | ( 45.55) | |
| TWX4 | 0.818 | 0.690 | 0.869 | 0.810 | 0.865 | 0.938 | 4.990 | 0.819 | 0.709 | 0.856 | 0.788 | 0.856 | 0.936 | 4.964 |
| | ( 41.43) | ( 14.80) | ( 44.38) | ( 29.05) | ( 48.56) | ( 93.25) | | ( 43.51) | ( 14.18) | ( 50.53) | ( 29.68) | ( 36.16) | ( 77.32) | |
| DLA/A-CAPX/A | 0.598 | 0.515 | 0.614 | 0.415 | 0.655 | 0.833 | 3.630 | 0.607 | 0.523 | 0.663 | 0.454 | 0.723 | 0.837 | 3.807 |
| | ( 6.81) | ( 4.63) | ( 17.56) | ( 6.37) | ( 7.60) | ( 19.66) | | ( 9.81) | ( 6.03) | ( 23.31) | ( 10.73) | ( 11.89) | ( 20.78) | |

R&D spending appears to be positively correlated with most benchmark variables, but the correlations are generally lower than those of other valid investment proxies. In fact, the correlation between R&D/A and ROA is insignificant. This insignificant relationship may arise because some firms have fewer incentives to invest in R&D when they are already quite profitable. In addition, R&D may result in cost savings rather than new products in some industries, leading to a relatively weak relationship between R&D investment and future sales growth. The relatively low correlation of R&D with future sales growth is also consistent with the notion underlying the generally accepted accounting principles (GAAP) that mandate accountants to write off R&D expenditures rather than capitalize them. Titman et al. find that abnormal investment is negatively correlated with abnormal future stock returns whereas Lev and Thiagarajan (1993) find that R&D is positively correlated with abnormal future stock returns. We find that these two investment variables differ dramatically in their correlations with firm profitability. The inherent uncertainty in the outcomes of R&D on firm sales might potentially account for the higher stock returns subsequent to investment. For instance, if the uncertainty associated with R&D investment is a priced risk in the market, then higher R&D should naturally lead to higher stock returns.

A firm's investment depends not only on firm-specific factors but also on industry-specific factors. We thus validate various investment proxies after adjusting for their industry medians each year. We follow the approach on Professor Kenneth French's website and classify firms into 48 industries (financial institutions and utility firms are excluded as firms in these industries are heavily regulated)[10]. Portfolio correlation results for industry-adjusted variables are reported in Panel B of Table 3.

In general, the correlations are similar or become slightly stronger after the industry adjustment. In Section II, we predict that the performance of CAPX/S should improve after industry adjustment. Results in Panel B of Table 3 generally confirm our prediction. Interestingly, one investment proxy that appears to become weaker after industry adjustment is R&D/A. This is consistent with our earlier notion that R&D is different from other capital investment proxies.

Table 4 summarizes the results about the robustness check of our empirical finding when we divide our sample period into four sub-periods: 1971 to 1980, 1981 to 1989, 1990 to 1999, and 2000 to 2008. For simplicity of exposition, we only report validation scores for each investment measure. In all four sub-periods, the empirical results are very close to the ones discussed in Table 3.

As a further check of the robustness of our findings, we repeat our analysis of the associations between investment proxies and sales growth using alternative sales growth measures calculated over five-year periods. The untabulated results remain qualitatively similar. We also examine the performance of depreciation expense as a deflator for investments. This is the deflator in Baber's construct. Depreciation expense potentially could be a good deflator, as depreciation is related to the balance of PPE. In addition, depreciation expense may reflect more recently purchased PPE (which is related to the replacement cost of PPE) if firms follow accelerated depreciation schedules. Nonetheless, firm discretion in accounting policies and the fact that some firms may have very small or even zero depreciation expense in some years can introduce significant noise into this variable. Untabulated results show that its performance generally does not surpass that of PPE.

**Table 4**
Validation scores between investment measures and benchmark variables:
Sub-period results

This table presents sub-period results of correlations between investment and validation benchmark variables. Each year we rank an investment measure into 50 portfolios based on its annual distribution. Firms ranked in the top 2% of firms are placed in portfolio 1, the next highest 2% firms are put into portfolio 2, and so on. We then compute the Spearman rank correlations between portfolio medians of the benchmark variables and portfolio medians of investment measures. Validation score (Valid. Score) is the sum of investment measures' correlations with Q, VGO, ROA, $SGRO_{-3}$, $SGRO_{+3}$, and EMPGR. This procedure is repeated for each year. The reported scores are means of validation scores in each sub-period.

| Sub-period Results | 1971-1980 | 1981-1989 | 1990-1999 | 2000-2008 |
|---|---|---|---|---|
| BABER | 5.177 | 5.071 | 4.486 | 3.640 |
| CAPXGRO | 3.094 | 3.908 | 4.324 | 3.746 |
| CAPX/A | 5.185 | 5.035 | 4.741 | 3.963 |
| CAPX/PPE | 5.228 | 5.285 | 5.079 | 4.537 |
| CAPX/S | 4.770 | 4.395 | 4.422 | 4.008 |
| CAPX/V | 1.109 | 0.392 | -0.860 | -1.031 |
| CAPX/V1 | 0.376 | -1.042 | -2.102 | -1.913 |
| CFI/A | 4.618 | 4.779 | 4.287 | 3.183 |
| DLA/A | 5.364 | 5.417 | 5.328 | 5.009 |
| INVTGRO | 4.867 | 5.059 | 5.062 | 4.503 |
| LAGRO | 5.401 | 5.465 | 5.349 | 5.168 |
| PPEGRO | 5.399 | 5.475 | 5.407 | 5.156 |
| PPEGGRO | 5.518 | 5.472 | 5.283 | 5.066 |
| R&D/A | 3.368 | 3.748 | 3.233 | 2.039 |
| TWX1 | 2.158 | 1.795 | 2.141 | 2.046 |
| TWX2 | 1.555 | 1.282 | 1.719 | 1.289 |
| TWX3 | 4.482 | 3.858 | 3.947 | 3.467 |
| TWX4 | 4.600 | 5.068 | 5.344 | 4.897 |
| DLA/A-CAPX/A | 2.066 | 3.706 | 4.422 | 4.228 |

### B. Investment Measures and Future Stock Returns

Recently, researchers have documented a significant relationship between capital investment and future stock returns. For example, Titman et al. (2004) applied four measures of capital investments, all related to future stock returns. If our validation tests are accurate, then more trustworthy investment measures should lead to higher investment-based hedge returns. We follow early studies and sort all available stocks on NYSE/AMEX/NASDAQ into ten portfolios at the end of April based on their recent annual capital investment measures.[11] Buy-and-hold returns in each portfolio are then measured for the 12 succeeding months. A hedge strategy involves buying stocks with the lowest decile of capital investment and shorting stocks with the highest decile of investment. The strategy is repeated each year over the sample period. Panel A of Table 5 presents average hedge returns of the strategy as well as returns of portfolios with the lowest, medium, and highest investments. Significance of stock returns is assessed by t-statistics.

Consistent with findings in other studies, stocks with high capital investments seem to underperform stocks with low capital investments over the one-year period after portfolio formation. However, different investment measures exhibit different performances. For example, among the four measures applied in Titman et al., average hedge returns can be as low as 5.3% for one investment measure with a validation score of 1.464 and as high as 12.4% for another measure with a validation score of 4.999.[12] There appears to be a monotonic relationship between validation scores and hedge profits among the four measures. For other investment measures, better-validated measures also tend to get higher hedge returns. For example, trading strategies based on CAPX/PPE, PPEGRO, and DLA/A generates hedge returns of 16.1%, 17.4%, and 19.4%, respectively. These measures have been shown in Table 3 as strong investment measures. In contrast, weak investment measures tend to get lower hedge returns. For example, hedge returns based on CAPX/V, CAPX/V1, and R&D/A are insignificant or even negative. Thus, refining investment measures could potentially improve investors' performance.

To understand whether or not the differences among investment-based trading strategies are explained by risk factors, we apply the Fama-French momentum-augmented four-factor model to run a time-series regression on annual portfolio returns. Specifically, we run the following regression to obtain the risk-adjusted return for each portfolio:

$$r_i - r_f = a_i + b_i\,(r_m - r_f) + s_i SMB + h_i HML + m_i UMD + e_i \tag{2}$$

where $r_i$ is the annual return for portfolio i, $r_f$ is the annualized T-bill return from Ibbotson and Associates, Inc., $r_m$ is the return on the NYSE/AMEX/NASDAQ value-weighted market index, SMB is the Fama-French small firm factor, HML is the Fama-French value factor, and UMD is the Fama-French momentum factor; $a_i$ is the intercept of the portfolio, $b_i$, $s_i$, $h_i$, and $m_i$ are the loadings on the market, small firm, value, and momentum factors, respectively. The data for these factors are downloaded from Professor Ken French's website.[13]

Panel B of Table 5 reports intercepts of the four-factor model for portfolios with different investment measures. The intercept of the regression can be regarded as the risk-adjusted return of the portfolio with respect to the Fama-French factor model. After risk adjustment, capital investment and future stock returns still exhibit a negative relationship for most investment measures. In addition, strong investment measures still lead to higher hedge returns than weak investment measures. For example, trading strategies based on CAPX/PPE, PPEGRO, and DLA/A generate risk adjusted hedge returns of 8.9%, 12.4%, and 12.1%, respectively, whereas strategies on CAPX/V, CAPX/V1, and R&D/A generate risk-adjusted hedge returns of 2.6%, -1.5%, and -2.5%, none of which is statistically different from zero.

The risk-adjusted hedge returns for strong investment measures, however, appear to be lower compared to gross hedge returns. A careful examination of the hedge portfolios' risk factor loadings in Panel C reveals that the hedge portfolios often have significant loadings on the small firm factor and the value factor. This suggests that low capital investments are often associated with small value firms instead of big glamorous firms. One exception is CAPX/V and CAPX/V1. Consistent with our previous analysis, low values of these measures may be explained by high market values in the denominators, and hence, are often related to glamorous stocks. Momentum factor loadings are not significant.

**Table 5**

Annual buy-and-hold stock returns for portfolios based on different measures of capital investment

This table presents average annual buy-and-hold stock returns from an investment-based portfolio strategy for the 1971 to 2008 time period. Each year, at the end of April, all available stocks on NYSE/AMEX/NASDAQ are sorted into ten portfolios based on recent annual capital investment measures. "Low" ("High") represents portfolios of the lowest (Highest) deciles of investment; "Medium" represents portfolios of investment deciles 5 and 6; "Low-High" represents hedge returns between the lowest and highest investments. Table values (except those in the last column) are average buy-and-hold annual stock returns. Numbers in parentheses are simple *t*-statistics for stock returns during the sample period. See Table 1 for description of investment measures. "Risk Adj. Return" represents the intercepts in the Fama-French four-factor regression model.

| | Panel A: Raw Returns | | | | Panel B: Risk Adj. Returns | | | | | Panel C: Low-High Factor Loadings | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low | Medium | High | Low-High | Low | Medium | High | Low-High | Mkt-Rf | SMB | HML | UMD | Adj. R-Squared |
| BABER | 0.211 | 0.157 | 0.104 | 0.107 | 0.027 | -0.014 | -0.035 | 0.061 | 0.214 | -0.130 | 0.892 | -0.185 | 0.293 |
| | (3.56) | (3.50) | (1.68) | (3.19) | (0.77) | (-0.76) | (-0.79) | (1.55) | (1.22) | (-0.56) | (3.92) | (-0.87) | |
| CAPXGRO | 0.211 | 0.162 | 0.091 | 0.121 | 0.028 | 0.001 | -0.046 | 0.074 | 0.205 | 0.389 | 0.476 | -0.029 | 0.089 |
| | (3.26) | (3.60) | (1.67) | (3.95) | (0.63) | (0.07) | (-1.60) | (1.80) | (1.13) | (1.60) | (2.01) | (-0.13) | |
| CAPX/A | 0.190 | 0.163 | 0.087 | 0.102 | -0.000 | -0.001 | -0.051 | 0.051 | 0.263 | 0.508 | 0.355 | 0.037 | 0.103 |
| | (3.16) | (3.42) | (1.70) | (3.24) | (-0.00) | (-0.04) | (-1.29) | (1.21) | (1.41) | (2.04) | (1.46) | (0.16) | |
| CAPX/PPE | 0.230 | 0.156 | 0.069 | 0.161 | 0.036 | -0.013 | -0.053 | 0.089 | 0.363 | 0.330 | 1.071 | -0.222 | 0.477 |
| | (3.56) | (3.56) | (1.25) | (4.67) | (0.86) | (-0.73) | (-1.67) | (2.52) | (2.33) | (1.59) | (5.29) | (-1.18) | |
| CAPX/S | 0.197 | 0.160 | 0.090 | 0.107 | 0.004 | 0.003 | -0.052 | 0.056 | 0.345 | 0.558 | 0.532 | -0.149 | 0.147 |
| | (3.22) | (3.51) | (1.65) | (2.86) | (0.13) | (0.16) | (-1.05) | (1.14) | (1.60) | (1.94) | (1.90) | (-0.57) | |
| CAPX/V | 0.146 | 0.171 | 0.145 | 0.001 | -0.013 | 0.005 | -0.039 | 0.026 | 0.223 | 0.134 | -0.624 | -0.048 | 0.202 |
| | (2.51) | (3.57) | (2.94) | (0.03) | (-0.36) | (0.21) | (-1.18) | (0.68) | (1.31) | (0.59) | (-2.81) | (-0.23) | |
| CAPX/V1 | 0.111 | 0.163 | 0.164 | 0.053 | -0.037 | -0.002 | -0.022 | -0.015 | 0.204 | 0.094 | -0.952 | 0.064 | 0.347 |
| | (1.92) | (3.36) | (3.27) | (-1.47) | (-1.11) | (-0.07) | (-0.57) | (-0.38) | (1.13) | (0.39) | (-4.03) | (0.29) | |
| CFI/A | 0.163 | 0.167 | 0.085 | 0.078 | -0.001 | -0.002 | -0.060 | 0.058 | 0.210 | 0.299 | -0.142 | 0.108 | 0.014 |
| | (2.75) | (3.44) | (1.68) | (2.54) | (-0.03) | (-0.10) | (-1.64) | (1.35) | (1.10) | (1.18) | (-0.57) | (0.47) | |
| DLA/A | 0.234 | 0.154 | 0.041 | 0.194 | 0.040 | -0.007 | -0.082 | 0.121 | 0.507 | 0.730 | 0.463 | -0.008 | 0.289 |
| | (3.37) | (3.48) | (0.85) | (5.31) | (0.83) | (-0.42) | (-2.60) | (2.79) | (2.64) | (2.86) | (1.86) | (-0.04) | |
| INVTGRO | 0.207 | 0.161 | 0.066 | 0.141 | 0.021 | -0.003 | -0.057 | 0.078 | 0.112 | 0.449 | 0.263 | 0.344 | 0.116 |
| | (3.41) | (3.82) | (1.32) | (5.17) | (0.47) | (-0.16) | (-1.83) | (2.16) | (0.71) | (2.12) | (1.27) | (1.78) | |
| LAGRO | 0.231 | 0.149 | 0.048 | 0.183 | 0.048 | -0.014 | -0.080 | 0.127 | 0.423 | 0.564 | 0.430 | -0.076 | 0.218 |
| | (3.25) | (3.71) | (0.91) | (5.53) | (0.97) | (-1.00) | (-2.77) | (3.07) | (2.32) | (2.32) | (1.81) | (-0.34) | |
| PPEGRO | 0.225 | 0.165 | 0.051 | 0.174 | 0.044 | -0.000 | -0.080 | 0.124 | 0.445 | 0.566 | 0.481 | -0.191 | 0.291 |
| | (3.18) | (3.72) | (0.98) | (5.38) | (0.93) | (-0.02) | (-2.76) | (3.21) | (2.63) | (2.51) | (2.18) | (-0.93) | |
| PPEGGRO | 0.211 | 0.165 | 0.057 | 0.153 | 0.023 | 0.001 | -0.073 | 0.096 | 0.236 | 0.368 | 0.745 | -0.101 | 0.334 |
| | (3.38) | (3.79) | (1.05) | (5.43) | (0.60) | (0.05) | (-2.43) | (2.95) | (1.64) | (1.92) | (3.99) | (-0.58) | |
| R&D/A | 0.143 | 0.167 | 0.152 | 0.009 | -0.015 | 0.021 | 0.010 | -0.025 | -0.284 | -0.856 | 1.426 | -0.363 | 0.365 |
| | (3.37) | (3.35) | (1.82) | (-0.14) | (-0.64) | (0.67) | (0.14) | (-0.35) | (-0.90) | (-2.03) | (3.47) | (-0.95) | |
| TWX1 | 0.193 | 0.174 | 0.120 | 0.074 | 0.028 | 0.006 | -0.036 | 0.064 | 0.323 | 0.504 | -0.064 | -0.196 | 0.212 |
| | (2.93) | (3.85) | (2.53) | (2.65) | (0.63) | (0.28) | (-1.57) | (1.84) | (2.10) | (2.46) | (-0.32) | (-1.05) | |
| TWX2 | 0.169 | 0.180 | 0.115 | 0.053 | 0.011 | 0.003 | -0.039 | 0.050 | 0.161 | 0.487 | -0.105 | -0.130 | 0.125 |
| | (2.66) | (3.67) | (2.41) | (2.06) | (0.21) | (0.12) | (-1.08) | (1.46) | (1.07) | (2.42) | (-0.54) | (-0.71) | |
| TWX3 | 0.186 | 0.164 | 0.095 | 0.091 | -0.014 | 0.014 | -0.047 | 0.033 | 0.338 | 0.559 | 0.479 | -0.026 | 0.067 |
| | (3.12) | (3.41) | (1.75) | (2.18) | (-0.47) | (0.55) | (-0.91) | (0.57) | (1.35) | (1.67) | (1.47) | (-0.09) | |
| TWX4 | 0.215 | 0.168 | 0.091 | 0.124 | 0.045 | 0.005 | -0.060 | 0.105 | 0.408 | 0.499 | 0.189 | -0.318 | 0.224 |
| | (3.21) | (3.94) | (1.90) | (3.95) | (0.99) | (0.29) | (-2.34) | (2.70) | (2.38) | (2.18) | (0.85) | (-1.52) | |

We highlight the relationship between hedge returns and validation performances for different investment measures in Figure 1. Figure 1(a) plots raw hedge returns; Figure 1(b) plots risk adjusted hedge returns. In both figures, there is an apparent pattern which shows that measures with higher validation scores generally achieve higher hedge returns. For example, in Figure 1(a), the four investment measures in Titman et al. (TWX1 to TWX4) exhibit a monotonic relationship. One measure that seems to deviate from the general pattern is R&D/A. It has a moderate validation score but very low hedge returns. This may be explained by the special accounting treatment of R&D investments. By the conservative accounting principle, R&D expenditures are immediately written off as expenses, not

**Figure 1**
The relationship between validation scores and investment-based hedge returns for various investment measures

These figures highlight the validation performance of various investment measures and the performance of investment-based hedge strategies. Figure 1(a) plots raw annual hedge returns from strategies described in notes to Table 5. Figure 1(b) plots risk-adjusted hedge returns. Note the low hedge returns associated with investment measure R&D/A.

**Figure 1a**

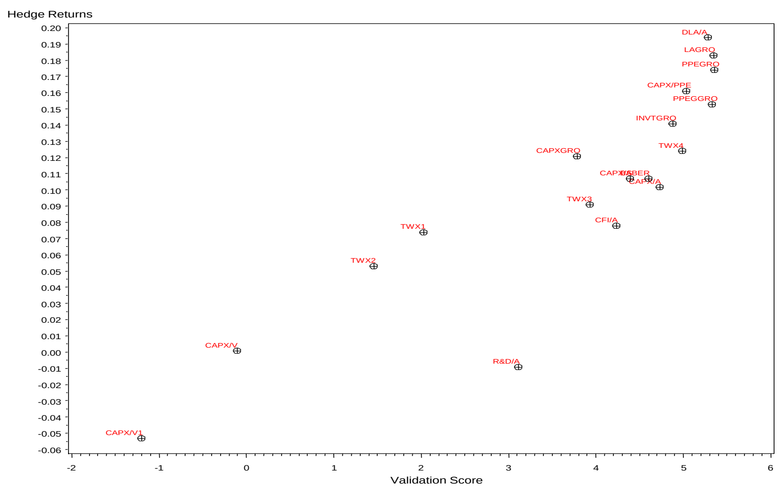
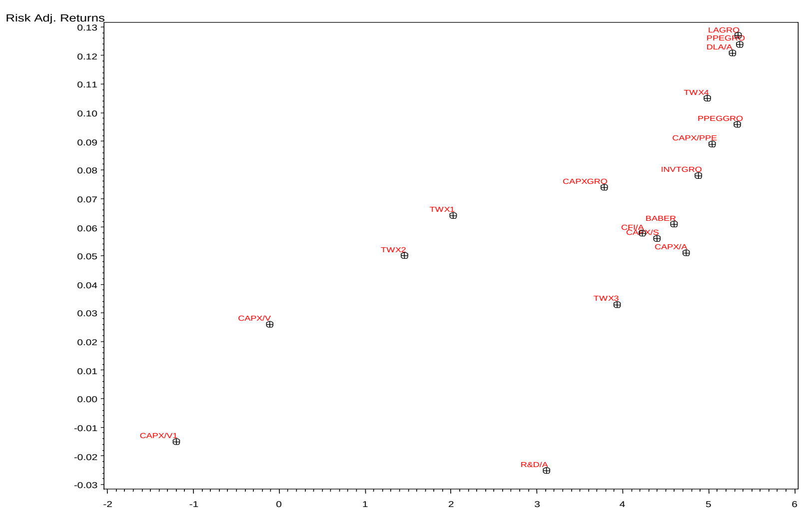



**Figure 1b**



capitalized. Previous studies (e.g., Penman and Zhang, 2002) have documented that investors may not fully understand the implications conservative accounting has on firms' earnings; hence, firms with high R&D expenditures may be undervalued, leading to higher future returns. This conservatism effect may neutralize the negative relationship between investment and future returns.

As a robustness check, we change the portfolio holding period to six month and find qualitatively similar results. In summary, validation performance of different investment measures is closely related to investment-based hedge returns. Refining investment measures could potentially enhance investors' performance.

### C. Industry Analysis

Because a firm's investment may be affected by industry-specific factors, it is possible that some investment proxies may perform well in some industries but not as well in others. Next, we attempt to identify relatively powerful investment proxies within each industry. For exposition convenience, we code all investment proxies from 1 to 17 (see Table 1). [14] In Table 6, we report the three most powerful investment proxies in Panels A, B, and C and the three least powerful proxies in Panels D, E, and F, based on their correlations with various benchmark variables. Consistent with results in Table 3, growth in PPE (PPEGGRO and PPEGRO, coded 12 and 11 respectively) appears to be very powerful in most industries, whereas capital expenditure deflated by firm value (CAPX/V, coded 6), R&D expenditure deflated by firm assets (R&D/A, coded 13) and abnormal capital expenditure deflated by sales (TWX2, coded 15) underperform in most industries. For example, in the manufacturing industry (Manuf), the consumer nondurable industry (NoDur), and the wholesale and retail industry (Shops), measures of growth in PPE (code 12 or 11) are the most or the second-most powerful by all benchmark standards. Interestingly, while R&D/A (coded 13) may be a powerful investment proxy based on its sensitivity to Q or VGO in some industries (e.g., health care and telecom industries in Panel A and the hi-tech industry in Panel B), it is a disappointing proxy in other industries (e.g., retail, wholesale, and consumer nondurable industries in Panel D). One explanation is that R&D expenditure may be a more important production force in the former industries but has a less important role in the latter. The above results may help researchers when they choose investment measures in different industries. It should also be noted that R&D appears to be a poor indicator of firm growth based on sales realization (retail & wholesale, energy, and telecom industries in Panel F). This is consistent with the notion that R&D investment outcome is inherently uncertain, the same notion underlying the generally accepted accounting principles that mandate recording R&D as an expense.

## V. CONCLUSION

In this study, we examine different measures of capital investment commonly applied in the finance literature and investigate their associations with future stock returns. Investment measures are validated based on their correlations with investment opportunity sets, future realized growth, and contemporary employee turnover. Results show that many of the capital investment variables constructed on capital expenditures and widely applied in the literature often underperform those constructed on simple

**Table 6**
Investment measures that have highest or lowest correlations with various benchmark variables in each industry

| Industry | No. of firms | Q | VGO | ROA | $SGRO_{-3}$ | $SGRO_{+3}$ | EMPGRO | Q | VGO | ROA | $SGRO_{-3}$ | $SGRO_{+3}$ | EMP GRO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Panel A Highest correlated investment measures | | | | | | Panel D Lowest correlated investment measures | | | | | |
| HiTec | 3006 | 12 | 12 | 17 | 12 | 12 | 12 | 6 | 6 | 13 | 15 | 15 | 15 |
| Other | 2179 | 1 | 1 | 11 | 12 | 9 | 9 | 6 | 6 | 13 | 15 | 15 | 15 |
| Manuf | 2096 | 12 | 13 | 11 | 12 | 12 | 12 | 6 | 6 | 13 | 15 | 15 | 15 |
| Shops | 1867 | 12 | 12 | 11 | 12 | 9 | 12 | 6 | 6 | 13 | 15 | 15 | 13 |
| Hlth | 1556 | 13 | 13 | 6 | 12 | 9 | 12 | 6 | 6 | 13 | 15 | 15 | 15 |
| NoDur | 1014 | 12 | 5 | 11 | 12 | 12 | 12 | 6 | 6 | 13 | 15 | 15 | 13 |
| Enrgy | 788 | 4 | 5 | 17 | 12 | 12 | 12 | 6 | 6 | 5 | 15 | 15 | 15 |
| Telcm | 488 | 13 | 13 | 14 | 12 | 12 | 12 | 6 | 6 | 13 | 15 | 15 | 13 |
| Durbl | 445 | 12 | 12 | 10 | 12 | 12 | 9 | 6 | 6 | 13 | 15 | 15 | 13 |
| | | Panel B 2nd Highest correlated investment measures | | | | | | Panel E 2nd Lowest correlated investment measures | | | | | |
| HiTec | 3006 | 4 | 13 | 11 | 4 | 11 | 11 | 15 | 15 | 16 | 14 | 14 | 6 |
| Other | 2179 | 4 | 13 | 10 | 11 | 12 | 12 | 15 | 15 | 6 | 14 | 14 | 16 |
| Manuf | 2096 | 10 | 12 | 10 | 11 | 10 | 11 | 15 | 15 | 16 | 14 | 14 | 16 |
| Shops | 1867 | 8 | 8 | 8 | 11 | 12 | 11 | 15 | 15 | 6 | 14 | 14 | 15 |
| Hlth | 1556 | 1 | 1 | 15 | 11 | 12 | 11 | 15 | 15 | 1 | 14 | 14 | 14 |
| NoDur | 1014 | 8 | 12 | 10 | 11 | 11 | 11 | 15 | 15 | 6 | 14 | 13 | 15 |
| Enrgy | 788 | 3 | 4 | 7 | 7 | 11 | 8 | 15 | 15 | 16 | 14 | 14 | 14 |
| Telcm | 488 | 4 | 4 | 15 | 5 | 8 | 11 | 16 | 15 | 5 | 14 | 14 | 15 |
| Durbl | 445 | 1 | 1 | 11 | 11 | 9 | 12 | 15 | 15 | 6 | 14 | 14 | 15 |
| | | Panel C 3rd Highest correlated investment measures | | | | | | Panel F 3rd Lowest correlated investment measures | | | | | |
| HiTec | 3006 | 10 | 4 | 10 | 11 | 10 | 10 | 14 | 14 | 5 | 6 | 6 | 14 |
| Other | 2179 | 12 | 4 | 8 | 4 | 11 | 11 | 14 | 14 | 16 | 2 | 6 | 13 |
| Manuf | 2096 | 4 | 4 | 4 | 4 | 8 | 10 | 14 | 14 | 5 | 2 | 6 | 14 |
| Shops | 1867 | 10 | 13 | 12 | 4 | 10 | 9 | 14 | 14 | 2 | 2 | 13 | 14 |
| Hlth | 1556 | 4 | 4 | 14 | 3 | 5 | 10 | 14 | 14 | 5 | 2 | 6 | 6 |
| NoDur | 1014 | 10 | 8 | 8 | 4 | 9 | 10 | 13 | 14 | 2 | 13 | 14 | 14 |
| Enrgy | 788 | 10 | 3 | 10 | 3 | 10 | 11 | 14 | 14 | 13 | 2 | 13 | 13 |
| Telcm | 488 | 10 | 12 | 17 | 11 | 10 | 8 | 15 | 14 | 16 | 13 | 13 | 14 |
| Durbl | 445 | 4 | 4 | 8 | 4 | 11 | 11 | 14 | 14 | 16 | 6 | 6 | 14 |

This table reports the three most and least powerful investment proxies (see codes in Table 1) in each industry, based on their correlations with various benchmark variables. We classify all non-financial non-utility firms into the following 9 industries.

1 NoDur Consumer NonDurables -- Food, Tobacco, Textiles, Apparel, Leather, Toys
0100-0999, 2000-2399, 2700-2749, 2770-2799, 3100-3199, 3940-3989
2 Durbl Consumer Durables -- Cars, TV's, Furniture, Household Appliances
2500-2519, 2590-2599, 3630-3659, 3710-3711, 3714-3714, 3716-3716, 3750-3751, 3792-3792, 3900-3939, 3990-3999
3 Manuf Manufacturing -- Machinery, Trucks, Planes, Chemicals, Off Furn., Paper, Com Printing
2520-2589, 2600-2699, 2750-2769, 2800-2829, 2840-2899, 3000-3099, 3200-3569, 3580-3621, 3623-3629, 3700-3709, 3712-3713, 3715-3715, 3717-3749, 3752-3791, 3793-3799, 3860-3899
4 Enrgy Oil, Gas, and Coal Extraction and Products 1200-1399, 2900-2999
5 HiTec Business Equipment -- Computers, Software, and Electronic Equipment
3570-3579, 3622-3622, 3660-3692, 3694-3699, 3810-3839, 7370-7372, 7373-7373, 7374-7374 , 7375-7375, 7376-7376, 7377-7377, 7378-7378, 7379-7379, 7391-7391, 8730-8734
6 Telcm Telephone and Television Transmission 4800-4899
7 Shops Wholesale, Retail, and Some Services (Laundries, Repair Shops) 5000-5999, 7200-7299, 7600-7699
8 Hlth Healthcare, Medical Equipment, and Drugs 2830-2839, 3693-3693, 3840-3859, 8000-8099
9 Other -- Mines, Constr, BldMt, Trans, Hotels, Bus Serv, Entertainment

accounting information. The choice of deflator may significantly affect the performance of capital-expenditure-based proxies. R&D spending is a good investment proxy in some industries but a poor proxy in others. We investigate several sources for the differences in performance of various investment proxies and documented that better-validated investment measures are more closely associated with future stock returns. The results may aid researchers in constructing investment proxies and help investors optimize investment strategies.

## ENDNOTES

1. Specifically, adjustment costs in investment are linearly homogeneous in investment.
2. Value of growth opportunity (VGO) is defined as the difference between firm value and asset-in-place. For details, see Richardson (2002).
3. We choose not to use growth in book value or earnings as the benchmark. Growth in book value firms may bias the test in favor of certain candidate investment proxies, e.g., growth in PPE.
4. The growth measure works better when potential fixed effects are present in other measurements. Thomas and Zhang (2002) apply a similar measure to proxy for investment: change in net PPE scaled by total assets.
5. The advantage of this measure is that it is most accurate in reflecting the cash spent in investing activities. A weakness of this measure is that it omits non-cash investing activities. Companies make investments that do not require cash. Non-cash investing activities can be reported in a separate schedule that accompanies the statement of cash flows. Hence, we anticipate this measure to be less powerful than growth in long-term assets or growth in PPE.
6. For details, see definitions of TWX1 to TWX4 in Table 1.
7. VGO is defined as the difference between equity value (Compustat data25*data199) and asset-in-place ($(1-\alpha r)BV+\alpha(1+r)X- \alpha rd$), where BV is the book value of common equity (data60), X is operating income after depreciation (data178), d is annual dividend (data 21), r is cost of capital 12%, and $\alpha$ takes the value of 1.24. By this construction, a higher X (ROA) may result in a lower VGO.
8. In general, we find that a beginning-of-year deflator works better than an end-of-year deflator. For exposition convenience, we do not present results for other variables with end-of-year deflators.
9. CAPX/A by construction may have a high correlation with ROA because ROA also has total assets in the denominator.
10. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
11. Most firms' annual reports are released to the public within four months of their fiscal year ends.
12. Titman et al. report that their untabulated results are not sensitive to investment measures. Differences in samples, sample periods, and return measurements might account for the difference between our findings and theirs.
13. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
14. CAPX/V1 is not coded, as it does not seem to be a valid investment measure at all.

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