Estimating Maintenance CapEx

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Abstract

Technological obsolescence has a more profound impact on the future economic life of long-term operating assets today than it had in the past. Therefore, the periodic capacity costs required to sustain current revenues should not only include the wear and tear costs of using long-term operating assets but also the costs related to their technological obsolescence. In reality, however, firms often record depreciation and amortization (D&A) expense that do not capture the effect of technological changes, resulting in misleadingly low D&A expense and overstated earnings. In this paper, I propose a measure of maintenance capex that attempts to measure the economic capacity cost required for a firm to sustain its current level of revenue. I find that the median firm recognizes 25% lower D&A expense compared to the estimated level of maintenance capex. This results in overstatement of operating income by 7%. I show that under-depreciating firms, which report lower D&A expense than their estimated maintenance capex, experience future write-offs and negative future earnings. Moreover, under-depreciation is also associated with significantly negative future abnormal stock returns, suggesting that stock prices do not fully reflect the implications of the under-depreciation for future earnings. In sum, my measure can help financial statement users identify under-depreciating firms, anticipate negative future earnings, and adjust reported earnings for valuation purposes. Additionally, I show that the well-documented negative relationship between investment and future stock returns is partly attributable to investors' inability to differentiate between maintenance and growth capex.

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1. Introduction

Investors rely on the information in GAAP earnings to form their expectation of future resource flows and hence firm value. However, GAAP earnings does not adequately account for the capacity costs expended to generate revenues. As an alternative, Warren Buffet introduced the "owner earnings" measure in his 1986 letter to Berkshire Hathaway Shareholders. He defined owner earnings as reported earnings plus depreciation, depletion, amortization, and other noncash charges, less the average annual maintenance capex, where maintenance capex is defined as the amount of capitalized expenditures for long-term operating assets that the business requires to fully maintain its current business. A major challenge in using this measure is that maintenance capex is not disclosed in the financial statements for most firms and rarely, if ever, disclosed for some firms. In this study, I propose a new method to estimate maintenance capex using publicly available information from financial statements. I also investigate the economic consequences of under-depreciation, which is the difference between estimated maintenance capex and reported depreciation and amortization expense. Specifically, I test whether under-depreciation predicts future write-offs and hence negative future earnings, and whether investors price this information.

Measuring maintenance capex is particularly important in the current era of rapid technological developments and shortening product cycles when firms must invest adequately in order to keep up with technological updates and stay competitive. It is important for investors to understand whether a firm has invested enough to replace technologically obsolete assets in a timely manner, as a firm that fails to do so may perform poorly in the future. Depreciation and amortization (D&A) expense can potentially provide such information about the future consumption of long-term operating assets. However, accounting D&A expense is primarily a method of allocating the historical cost of these assets and does not reflect the economic cost required to operate the firm in its current form. This limitation of D&A expense motivates this paper, which aims to estimate the economic capacity cost required to sustain a firm's current level of sales.

This study is most closely related to the literature on estimating the rate of economic depreciation (e.g., Taubman and Rasche, 1969; Wykoff, 1970; Hulten and Wykoff, 1981). However, these studies use the historical trend of market prices of a particular asset in a hand collected sample to estimate economic depreciation. Such an approach is not feasible for a large sample of firms where each firm has a complex collection of assets on its balance sheet acquired at various times in the firm's history.

My method is based on the understanding that the economic costs of using a long-term operating asset not only includes the loss in value of the asset due to wear and tear, but also any loss in value due to technological obsolescence. Under GAAP reporting, D&A expense merely allocates the historical cost of a long-term asset over a pre-determined useful life and does not measure the deterioration of the asset or changes in its market value (Kieso et al., 2007). Firms do not usually change their depreciation/amortization schedules when technological developments shorten the actual useful life of an asset, and instead take one-time impairments and write-downs after the asset has become technologically obsolete. As such, D&A expense will likely be lower than the economic capacity cost of generating current revenues. Because GAAP earnings does not reflect the economic capacity cost, investors who rely on GAAP earnings may overestimate the future profitability of a firm.

To overcome this problem, one could estimate the economic capacity costs by aggregating the D&A expense and the amount of write-downs and impairments on an annual basis. However, impairments and write-downs are not timely and are frequently recognized with a lag with respect to information arrival. Moreover, they are lumpy and may not occur every period. Hence summing D&A expense and the amount of write-downs and impairments on an annual basis would not serve as a good estimate for maintenance capex. Furthermore, such a measure at a firm level is bound to be noisy given the managers' discretion in estimating useful lives and salvage values, taking large impairments before they are due and/or overpaying for unproductive acquisitions.

In my model, I try to address these issues by accumulating the information on traditional mortality (i.e, D&A expense) and technological obsolescence (i.e, write-downs & impairments) over a sufficiently long period of time (five years). For each firm-year, cumulative capacity costs and cumulative sales are obtained by summing the capacity costs and sales respectively over the last five years. The cumulative capacity costs are then regressed on cumulative sales by industry and year. Further, in order to accommodate the firm level heterogeneity in business models, cost structures and business life cycles, I augment the above model with five important characteristics that could affect the relationship between capacity costs and sales. These characteristics are the degree of operating leverage, firm age, operating lease intensity, goodwill intensity and SG&A intensity. To control for the effect of all these firm characteristics on the relationship of cumulative capacity costs and cumulative sales, I interact each of these characteristics (averaged over last five years) with cumulative sales in the regression. The predicted value of cumulative capacity costs from the above regression is then divided by cumulative sales and multiplied by the current year sales to get a dollar estimate of economic capacity costs required to sustain current year sales.

I validate my measure of maintenance capex by documenting that under-depreciation, which is the unrecognized portion of maintenance capex computed as estimated maintenance capex minus reported D&A expense, predicts negative future earnings and negative future stock returns. First, I examine whether under-depreciation is associated with future write-downs and hence lower future earnings over the next one to three years. If a firm assumes the useful life for an asset to be so long that the resulting D&A expense is too low to match the pace of its technological obsolescence, then the firm's D&A expense should be lower than my estimate of maintenance capex. This, in turn, suggests that the firm will have to write-down the asset in the future when it can no longer be used. Therefore, I expect under-depreciation to be associated with future write-downs and hence lower future earnings. Consistent with these expectations, I find that higher under-depreciation is positively associated with future write-offs and negatively associated with future earnings in each of the three subsequent years.

Next, I investigate whether my measure of under-depreciation predicts future negative stock returns. Specifically, given my finding that the under-depreciation measure has predictive power for future earnings, future stock returns will reflect whether investors are systematically surprised by such predictable information. If the market fully incorporates the information about under-depreciation, stocks prices in the current period will correctly reflect the implications of under-depreciation for future earnings, leading to no future abnormal returns. Alternatively, if the market does not fully incorporate information about under-depreciation, stocks may be mispriced in the current period, leading to possible future abnormal returns. Consistent with these predictions, I find a negative association between under-depreciation and future abnormal returns. Furthermore, I find that a trading strategy of going long on highest decile portfolio and short on lowest decile portfolio of under-depreciation generates negative returns. The average values of equal-weighted (value-weighted) annualized raw returns are -4.38% (-3.60%). The average values of equal-weighted (value-weighted) annualized alphas are -3.97% (-3.35%) and -3.72% (-2.89%) in the Carhart four factor model and the Fama and French five factor model, respectively. These findings indicate that investors underestimate the effect of under-depreciation on future earnings.

Finally, I test whether my measure of maintenance capex can partly explain the negative relationship between asset growth and future stock returns. This relationship has been studied extensively, and prior studies provide two major explanations. One is a behavioral explanation, where investors tend to underreact to the empire building implications of increased investment expenditures (Titman et al., 2004). The other is a risk-based explanation, where investors require less risk premium after the growth options have been exercised by the firm (Cooper and Priestley, 2011). While I do not contest these explanations, I posit that the negative relationship between investment and future stock returns could be partly explained by the inability of investors to understand how much of the current investment is for maintenance and how much of it is for growth.

If investors were unable to distinguish between maintenance and growth capex and perceive the entire investment as growth capex, then they would overreact to the current investment and act as though they were surprised in the future when earnings growth falls below their expectations. Therefore, for a given level of current investment, I expect firms that incur larger maintenance capex to experience negative future returns. To test this prediction, I re-examine the relationship between investment and future stock returns by interacting investment with maintenance capex. I find that the relationship is more negative for firms with high maintenance capex. This finding confirms the explanation that investors may have overreacted to current investments because they were unable to distinguish between maintenance and growth capex.

To the best of my knowledge, this study is the first to propose an empirical measure to estimate maintenance capex for a large sample. Using this measure, I find that (1) my measure of under-depreciation predicts future write-offs and hence lower future earnings, (2) under-depreciation is associated with significantly negative future returns, implying that stock prices do not fully reflect the implications of under-depreciation for future earnings, and (3) the negative relationship between asset growth and future stock returns can partly be explained by investors' inability to estimate the maintenance portion of current investments.

The remainder of the paper is organized as follows. In section 2, I discuss the background and prior literature. In section 3, I describe the methodology used to estimate maintenance capex. In section 4, I describe the data used in my analysis and discuss the sample statistics for the main variables. In section 5, I present the results for validating my measure using future write-offs and future earnings. In section 6, I present the results that document the implication of under-depreciation for future stock returns. In section 7, I examine the implication of maintenance capex for partly explaining the negative relationship of investment and future stock returns. Section 8 concludes.

2. Background and Prior Literature

The most common non-GAAP metric of profitability used by practitioners and academics is EBITDA (i.e., earnings before interest, taxes, depreciation, and amortization). Proponents of this measure argue that D&A expense reduces the comparability of earnings across firms and over time for the following reasons: (i) D&A is a non-cash expense as the corresponding cash outflow has already occurred in the past; (ii) these expenses are measured at historical cost and do not represent the current expense for generating the current revenues; (iii) D&A expenses are subjective as firms can use substantial discretion in specifying the assets' useful lives, salvage values and method of depreciation; (iv) the timing of asset purchases also varies across companies. They therefore contend that .

The downside to the above argument is that EBITDA excludes the cost of fixed assets used in operations and results in inflated profitability. In his 2002 Letter to Berkshire Hathaway Shareholders, Warren Buffet explains the importance of D&A expense in the below quote:

> *"Trumpeting EBITDA (earnings before interest, taxes, depreciation and amortization) is a particularly pernicious practice. Doing so implies that depreciation is not truly an expense, given that it is a "non-cash" charge. That's nonsense. In truth, depreciation is a particularly unattractive expense because the cash outlay it represents is paid up front, before the asset acquired has delivered any benefits to the business. Imagine, if you will, that at the beginning of this year a company paid all of its employees for the next ten years of their service (in the way they would lay out cash for a fixed asset to be useful for ten years). In the following nine years, compensation would be a "non-cash" expense – a reduction of a prepaid compensation asset established this year. Would anyone care to argue that the recording of the expense in years two through ten would be simply a bookkeeping formality?"*

Given this problem, a better measure for assessing long term profitability is owners' earnings. This term was introduced by Warren Buffet in his 1986 letter to Berkshire Hathaway Shareholders. He defined owner earnings as reported earnings (net income) plus depreciation, depletion and amortization plus/minus other noncash charges less the average annual maintenance capex, where maintenance capex is defined as the amount of capitalized expenditures for long-term operating assets that is required for a firm to sustain its current business. Even though this definition of operating earnings is superior to EBITDA as a measure of long-term profitability, it presents a new challenge of estimating maintenance capex as it is not disclosed (or only partially disclosed) in the financial statements.

The simplest proxy for maintenance capex is the D&A expense reported under GAAP accounting. Richardson (2006) uses reported D&A expense as a proxy for maintenance capex and calls the difference between total investment and maintenance capex as growth capex. However, D&A expense is only intended to distribute the historical cost of long-term operating assets, and the depreciation schedules do not necessarily line up with actual useful lives. Most (1984) finds that the economic lives of depreciable assets for U.S. firms tend to be shorter than the useful lives selected for accounting depreciation. Hence D&A expense may not serve as a good proxy for the true economic cost of current revenues. Warren Buffet acknowledges this issue in his 2018 Letter to Berkshire Hathaway Shareholders.

> *Berkshire's $8.4 billion depreciation charge understates our true economic cost. In fact, we need to spend more than this sum annually to simply remain competitive in our many operations. Beyond those "maintenance" capital expenditures, we spend large sums in pursuit of growth.*

Another potential proxy for maintenance capex is the amount of total capital expenditure reported in a year. However, this measure may also not be a good estimate of maintenance capex because it may include expenditure for growth. Dennis et al. (1999) investigates the use of capital expenditure as an alternative measure of depreciation. They find that adjusting earnings by substituting current capital expenditures for reported depreciation reduces the usefulness of earnings as an indicator of share value. They show that the gap in explanatory power between reported and adjusted earnings is largely due to the lumpiness and expansion problems associated with capital expenditures. Even after using the average of current and past capital expenditure to correct capital expenditures for the effects of lumpiness and expansion, reported earnings continues to explain significantly more of the distribution of prices than adjusted earnings.

Measuring maintenance capex requires an understanding of the concept of economic rate of depreciation. Economic depreciation can be defined as the loss in productive capacity of a depreciable asset. Typically, one would expect the older assets to be less productive than the newer ones for three reasons: (1) the remaining useful life is lower for the older assets, (2) older assets may be less profitable because they either produce less output or they require more input to operate and (3) older assets may be more prone to loss of value due to technological obsolescence. Accounting depreciation, on the other hand, relies on allocating the cost of an asset over time according to a pre-determined useful life. Because of this divergence between the economic and accounting depreciation, considerable efforts have been made in the past to estimate the true rate of economic depreciation.

There are two basic approaches to the measurement of economic depreciation generally discussed and estimated in the literature. Broadly categorized, they include: (i) studies which use market (or rental) price data and (ii) studies that use capital stock data, i.e., use quantities rather than price data. Both approaches use data generated from the history of a particular asset. Taubman and Rasche (1969) compute the value of office buildings as the present discounted value of its future revenues net of repairs. They term the change in this value from time to time as economic depreciation. Wykoff (1970) computes the economic depreciation of automobiles as the cost of using the car for a year, which includes the change in price of the car from beginning to the end of the year plus the opportunity cost of using one's wealth of holding the car for the year. Hulten and Wykoff (1981) obtain the used market prices of various physical assets, map them with their age and compute the rate of economic depreciation as the elasticity of asset price-age curve. The Bureau of Economic Analysis, on the other hand, uses a capital stock methodology which focuses on physical quantities rather than prices. They employ the perpetual inventory method and estimate gross investment and service lives to derive measures of gross stocks (see Bureau of Economic Analysis [1976, pp. 3- 4]). Capital consumption allowances are then derived by applying straight-line depreciation rates to gross stocks reduced by hypothetical retirements.

The above studies, however, derive economic depreciation for very specific asset classes. These methods cannot be applied on a firm level because the firms' assets comprise of many different types. A generalized approach is hence needed to derive a measure for economic depreciation on a firm-year basis. Formulation of such an approach would always involve a tradeoff between accuracy and feasibility.

In this study, I propose and test a generalized approach to estimating annual maintenance capex on a firm-year basis. The methodology of this approach is described in the next section.

3. Methodology

I define annual maintenance capex as the per period capacity cost incurred from the usage or retirement of long-term operating assets (both tangible and intangible) that is necessary to sustain current business and is expected to vary with revenues (Dichev and Tang 2008, Donelson et al. 2011). In this paper, I propose a methodology to estimate annual maintenance capex that: 1) captures both the periodic wear and tear cost and technological obsolescence cost of long-term operating assets, 2) benchmarks these costs with respect to a common group operating in a similar business and 3) incorporates the firm characteristics that cause variation in these costs across the cross section of firms and also for a particular firm over time. I elaborate on each of these features in the following paragraphs.

The first important feature of my maintenance capex measure is that it includes the loss in service value incurred in connection with the consumption or prospective retirement of a long-term operating asset, which generally results from two major factors: traditional mortality forces and technological obsolescence. The traditional mortality forces include normal wear and tear and deterioration of the asset over its useful life. Accounting standards require firms to estimate this cost by anticipating the asset's useful life, salvage value and method of depreciation/amortization (straight line or accelerated) and expense it in the income statement through D&A expense. Despite having considerable discretion in determining these parameters, firms generally follow their industry peers in assigning depreciation schedules to similar assets. However, firms seldom change their depreciation schedules with the arrival of new information. This new information could be about technological obsolescence or shortened product life cycle. These forces result in impairments and write-downs in the value of the assets. However, such impairments or write-downs are not timely and are frequently recognized with a lag with respect to information arrival. Moreover, these impairments or write-downs are lumpy and may not occur every period. Hence summing D&A expense and the amount of write-downs and impairments on an annual basis would not serve as a good proxy for maintenance capex. In order to address these issues, the proposed measure for maintenance capex accumulates the information on traditional mortality (i.e., D&A expense) and technological obsolescence (i.e., write-downs & impairments) over a sufficiently long period of time (five years) to get a dollar estimate of these costs per dollar of sale generated during the same period. Specifically, for each firm-year, I compute cumulative capacity cost as the sum of D&A expense, asset write-downs, loss on sale of assets, goodwill, and intangible asset impairments over the last five years (*t-4 to t*). The cumulative capacity cost is then divided by sales cumulated over the same period resulting in an average firm specific estimate of the cost of long-term operating assets required to generate a dollar of sale, which I refer to as *"Capcost_ratio"*. To compute the dollar amount of maintenance capex for the current year, I multiply the *Capcost_ratio* with the current-year sales. This measure uses the firm's most recent information from the last five years on the loss of value in long-term operating assets to estimate an approximate value of maintenance capex required to sustain the firm's current revenues.

The second feature of the model is to benchmark the capacity costs with respect to the industry group to which the firm belongs. This is required as the firm specific *Capcost_ratio*, computed as described above, may not represent the true economic cost required to sustain current revenues. First, the reliability of reported D&A expense is often questioned because of the managers' discretion in estimating useful life and salvage value. Second, since these estimates are difficult to audit, managers tend to use them to manipulate the level of reported earnings over a long horizon (Hanna and Vincent 1996). Third, write-downs and impairments could cause *Capcost_ratio* to be overestimated if firms engage in big bath behavior (Riedl 2004) and take an impairment before it is due, or the impairments could result from overpaying for acquisitions or unproductive investment outlays. In order to mitigate the potential bias in the *Capcost_ratio*, I regress cumulative capacity costs on cumulative sales by industry and year and compute an industry- and year-adjusted ratio by dividing the predicted value from the regression by cumulative sales.

The above procedure, however, assumes that all the firms in an industry have similar composition of assets, similar cost structures and are in similar business life cycles. This is certainly not true. The third feature of my estimate is that it takes into account five key characteristics that could affect the relationship between cumulative capacity costs and cumulative sales. These characteristics are the degree of operating leverage, firm age, operating lease intensity, goodwill intensity and SG&A intensity.

A higher degree of operating leverage (measured as fixed to variable cost ratio) indicates higher fixed costs and hence higher *Capcost_ratio*. Firm age can proxy for both the business life cycle and the used life of its long-term assets. For example, older firms are more likely to be in the mature stage of business life cycle and have a larger number of older assets on their balance sheets. Hence these firms are expected to have lower *Capcost_ratio*. Higher operating lease intensity (measured as the ratio of present value of operating lease commitments to total assets) reflects greater dependence on off-balance sheet assets to generate sales. Therefore, firms with high operating lease intensity are likely to have lower *Capcost_ratio*. Higher goodwill intensity (measured as the ratio of goodwill to total assets) suggests that a firm generates more sales from acquisitions compared to firms that depend mainly on organic growth. The effect of goodwill intensity on *Capcost_ratio* can go either way. Firms with high goodwill intensity could have higher *Capcost_ratio* as they recognize the acquired tangible and intangible assets on the balance sheet at fair value, which are periodically expensed as D&A expense. However, if such firms understate the fair value of the acquired assets and instead record the acquired value as goodwill, then the periodic D&A expense could be lower till the time goodwill is impaired. Such practices will result in lower *Capcost_ratio*. Finally, firms with high SG&A intensity (measured as the ratio of SG&A expense[1] to total operating expenses) are likely to have higher *Capcost_ratio* because they would need more long-term operating assets to support such investments.

To control for the effect of all these firm characteristics on the relationship of cumulative capacity costs and cumulative sales, I interact each of these characteristics (averaged over last five years) with cumulative sales in the regression. Accordingly, I estimate the below regression by industry and year:

$$Capacity\ costs_{i,t-4\ to\ t} = \beta_{0,Ind,t} + \beta_{1,Ind,t}Sales_{i,t-4\ to\ t} + \sum\beta_{j,Ind,t}Controls_{i,t} + \sum\beta_{k,Ind,t}Sales_{i,t-4\ to\ t} * Controls_{i,t} + \varepsilon_{i,t} \quad \textit{(Eq. 1)}$$

where i denotes the firm, Ind denotes the industry, and t denotes the year. Capacity cost is measured as the sum of depreciation and amortization expense (DP), goodwill impairment (GDWLIP), asset write-downs (WDP), loss on sale of assets (GLP) and asset write-downs included in special items[2] (SPI). Capacity costs and sales (SALE) are cumulated over the last five years and scaled by the average of the beginning and the ending total assets (AT) for the year *t*. Industry is defined using the Fama and French 48-industry classification (Fama and French 1997). Controls include the degree of operating leverage, log of firm age, operating lease intensity, goodwill intensity and SG&A intensity. To be consistent with the cumulative capacity costs and sales, each of the control variables are averaged over the last five years. All variables are defined in detail in the Appendix. Finally, annual maintenance capex is estimated using the following equation:

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[1] Includes R&D expense

[2] Asset write-downs in special items is computed as SPI-sum (AQP, GLP,GDWLIP,SETP,RCP,WDP,DTEP,RDIP,SPIOP,0)

$$Maintenance\ capex_{i,t} = \left(\frac{Capacity\ \widehat{costs}_{i,t-4\ to\ t}}{Sales_{i,t-4\ to\ t}}\right) * Sales_{i,t}, \qquad \textit{(Eq. 2)}$$

where $Capacity\ \widehat{costs}_{i,t-4\ to\ t}$ is computed using the following equation:

$$Capacity\ \widehat{costs}_{i,t-4\ to\ t} = \hat{\beta}_{0,Ind,t} + \hat{\beta}_{1,Ind,t}Sales_{i,t-4\ to\ t} + \sum\hat{\beta}_{j,Ind,t}Controls_{i,t} + \sum\hat{\beta}_{k,Ind,t}Sales_{i,t-4\ to\ t} * Controls_{i,t} \qquad \textit{(Eq. 3)}$$

The intercept in Equation (3) can be interpreted as an approximation of the industry-average technology obsolescence cost over the last five years. Therefore, the predicted cumulative capacity costs incorporate the costs required to keep pace with the technological developments taking place in an industry over time.

The above estimation procedure allows the estimated cumulative capacity costs to capture both total wear and tear costs and technological obsolescence costs incurred over the last five years, which are required to generates sales over the same period. Therefore, annual maintenance cost gives a better estimate of the true capacity costs needed to maintain the current year revenues. This estimate could be underestimated because the inputs to the model are historical costs and the current replacement costs could be higher due to inflation. However, this estimate is a better approximation of the true capacity costs compared to D&A expense as it captures industry-average technological obsolescence costs also.

4. Data and Sample Statistics

4.1 Data

My sample consists of all firms that are incorporated in the U.S., have common shares trading on NYSE, Amex, or NASDAQ, and have all the required data available on CRSP monthly return files and Compustat annual files. My sample period starts from 1974 because data on operating leases was not available before this year. The sample ends in 2016 because I need the next three years' data to compute future earnings, write-downs, and investments. To compute my measure of maintenance capex, I require each firm-year in the sample to have accounting data available on Compustat for the past five years. I exclude the financial services industry (industry number 44 to 47 using the Fama and French 48-industry classification) as firms in these industries differ from firms in other industries in their cost structures and business models. I also exclude the category called "almost nothing" (industry number 48) because of the difficulty in interpreting the results in an industry context. Further, to reduce the influence of very small firms, I also exclude firms with negative book equity, stock price less than $1 and have less than $10 million of sales.

4.2 Sample Statistics

4.2.1 Capcost_ratio and Firm Characteristics

Panel A of Table 1 presents the descriptive statistics of *Capcost_ratio*, which is the ratio of cumulative capacity costs to cumulative sales, and other firm characteristics that are used as controls in the model for estimating maintenance capex. The mean (median) value of *Capcost_ratio* is 0.07 (0.04) indicating that on an average, firms incur approximately 7 cents (4 cents) of capacity costs for 1 dollar of sales. Panel B of Table 1 shows that the capacity costs have been steadily increasing from 4 cents for a dollar of sales in 1974 to 8 cents in 2016. Panel C of Table 1 reports the time series average of yearly cross-sectional mean of *Capcost_ratio* by industry. Precious Metals industry has the highest *Capcost_ratio* of around 21 cents. Petroleum & Natural Gas has the next highest value of 19 cents following by Communication industry with 17 cents. Retail industry has one of the lowest values of *Capcost_ratio* at 3 cents. Firms in this industry rely heavily on operating leases[3]. The average operating lease intensity of firms in this industry is 19%, whereas the mean value for the entire sample is only 7%. Also, the business model of retail firms has changed significantly in the recent times with the advent of ecommerce.

Table 1 also presents the descriptive statistics, time trend and industry mean of the firm characteristics. *Dol_5y* is the degree of operating leverage obtained using firm specific time series regressions of total operating costs on sales (Aboody, Levi and Weiss 2018). A high degree of operating leverage indicates that a firm has a high proportion of fixed costs to variable costs. The mean (median) value of *Dol_5y* for the entire sample is 0.07 (0.03). Operating leverage increases monotonically over the sample period to an average of 0.14 in the year 2016. A potential explanation for this time trend is the increase in outsourcing activities over the last two decades. Among all the industries, pharmaceutical products, precious metals, and metals & mining have the highest operating leverage. Once again retail industry has one of the lowest operating leverage at 0.03. *Opl_intst_5y* is the ratio of operating leases to total assets averaged over the last five years. The mean (median) value for the entire sample is 0.06 (0.03). Operating lease intensity also has steadily increased over the years from 0.01 in 1974 to 0.07 in 2016. Some of the industries with high operating lease intensity are Retail (0.19), Restaurants, Hotels, Motels (0.18), Personal services (0.13) and Transportation (0.10). *Gdw_intst_5y* is the ratio of goodwill to total assets averaged over the last five years. The mean (median) value for the entire sample is 0.05(0). The first year where goodwill intensity is non-zero is 1988. Very few firms booked goodwill on their balance sheets in that year. Goodwill intensity increased significantly after the

[3] I did not include rental expense on operating leases in the capacity costs.

release of SFAS 141[4] and SFAS 142[5] in 2001 reaching an average of 0.14 in 2016. This shows that acquisition led growth has become more prominent in the latter part of the sample period. *Sga_intst_5y* is the ratio of SG&A expense to total operating costs averaged over the last five years. The mean (median) is 0.22 (0.19). This ratio has also increased monotonically over the sample period from 0.17 in 1974 to 0.25 in 2016 (Enache and Srivastava 2018).

Each of the firm characteristics described above could influence the relationship between capacity costs and sales. Panel D of Table 1 reports the results of univariate and multivariate regressions of these characteristics on *Capcost_ratio*. The coefficient on the degree of operating leverage is positive and significant, which is consistent with my expectation that firms with higher operating leverage have higher proportion of fixed costs to variable cost and hence higher capacity costs. The coefficient on firm age is negative and significant. This indicates that older firms have lower capacity costs. Older firms tend to be larger and in the mature stage of its life cycle. Hence one would expect such firms to benefit from economies of scale and have lower capacity costs. The coefficient on operating lease intensity is negative and significant confirming that firms with higher reliance on operating leases will have relatively fewer assets on the balance sheet and hence lower capacity costs (rental expense is excluded from capacity costs). The coefficients on goodwill intensity and SG&A intensity are not significant both in univariate and multivariate regressions. However, I retain them in the model to estimate maintenance capex.

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[4] SFAS 141 eliminated the alternative pooling-of-interests method of accounting for acquisitions. The popularity of pooling stemmed largely from the fact that it did not require the recognition of goodwill and the associated amortization charges. Post this rule, managers must recognize goodwill.

[5] Prior to the release of SFAS 142 in 2001, APB Opinion No. 17 governed the accounting for goodwill (AICPA 1970). APB 17 required goodwill to be amortized to operating income over its estimated useful life, subject to a maximum life of 40 years.

4.2.2 Maintenance CapEx

Table 2 Panel A reports the descriptive statistics for the estimated maintenance capex. *Mcap_ratio* is the ratio of estimated annual maintenance capex to annual sales. The mean (median) of *Mcap_ratio* is 0.067 (0.045). The first quartile value is 0.028 and third quartile value is 0.075. To put this value in perspective, the mean (median) value of *Dp_ratio* (ratio of reported D&A expense to sales) is 0.053 (0.034). Therefore, the mean (median) value of *Underdep_ratio* (difference between estimated maintenance capex and D&A expense divided by annual sales) is 0.013 (-0.003). In percentage terms, the median firm seems to be under-depreciating by 25% of the reported D&A expense.

Table 2 Panel B reports the descriptive statistics for the estimated maintenance capex and under-depreciation by size. The mean (median) of *Mcap_ratio* is 0.059 (0.043) for small firms, 0.07 (0.049) for medium firms and 0.076 (0.054) for large firms. Compared to the estimated maintenance capex value, the recognized D&A expense of a median firm is lower by 32% in the small size category, 26% in the medium size category and 19.6% for the large size category.

Table 2 Panel C reports the time trend of estimated maintenance capex and under-depreciation. The mean (median) value of *Mcap_ratio* increased from 0.038 (0.027) in 1974 to 0.081 (0.055) in 2016. The percentage of under-depreciation is high for years during and immediately after a crisis mainly because of the incidence of impairments and write-downs during the crisis period. Since the estimation procedure includes the write-downs and impairments for the last five years, one would observe higher estimated maintenance capex when the last five years overlap with the crisis period. The higher maintenance capex reflects the fact that a crisis year increases the rate of technological obsolescence and renders old assets unproductive. As a result, firms need to replace these assets with new assets that are equipped with new technology. Any firm that delays this process is more likely to lose out to competition.

Table 2 Panel D reports the time series average of yearly cross-sectional mean (median) values of estimated maintenance capex and under-depreciation for different industries. Some of the major industries with the percentage of under-depreciation above the sample median (25%) are Pharmaceutical Products (47.5%), Construction (63.5%), Healthcare and Medical equipment (39%), Business Services (59.4%), Computers (56%), Electronic equipment (49.6%) and Wholesale (52%). These are the industries which experienced a higher rate of technological obsolescence and disruption to their business during the sample period. My measure of maintenance capex and under-depreciation suggests that firms in these industries should reduce their current estimates of useful lives for their long-term operating assets, such that their reported D&A expense can reflect timely information of capacity costs needed for every dollar of sale generated.

5. Validation Using Future Write-offs and Future Earnings

In this section, I validate my measure of maintenance capex by showing that firms that do not recognize sufficient expense for maintenance capex will have to write off their assets in the future. To do that, I first compute the amount of under-depreciation, which is the difference between the estimated maintenance capex and the recognized D&A expense. A positive value of under-depreciation indicates that the D&A expense in the income statement understates the true capacity costs expended to generate the current year revenues, and the current period earnings are therefore overstated. Specifically, I examine whether the level of under-depreciation is associated with future write-offs and hence lower future earnings over the next one to three years.

5.1 Future Write-offs

Matching principle requires that the expense related to the usage of all capitalized long-term operating assets should be recognized in the same period in which the related revenues are earned. However, these costs are less timely due to managers' discretion in allocating them across time periods. Managers tend to postpone these costs to future periods in order to show higher income in the current period. If my measure of under-depreciation is a good proxy for such postponement of capacity costs recognition, then we should observe larger write-offs for the under-depreciating firms in the future. To test this, I examine the following tobit regression:

$$Future\_writeoffs_{i,t+k} = \beta_0 + \beta_1 Underdep_{i,t} + \beta_2 Writeoff_{i,t} + \sum \beta_j Controls_{i,t} + \varepsilon_{i,t+k}$$

(Eq. 4)

Write-offs in the above equation are computed as the sum of goodwill impairment (GDWLIP), asset write-downs (WDP), loss on sale of assets (GLP) and asset write-downs included in special items (SPI) scaled by beginning total assets. I use four proxies for future write-offs including the write-offs for year t+1, t+2, and t+3, and excess future write-off computed as the average of the next three years' write-offs minus the current year write-offs. Consistent with Hanna and Vincent (1996) , I control for current write-offs, log of sales, industry-adjusted book-to-market ratio of the current year, mean change in book-to-market ratio over the last five years, mean change in the firm's industry median book-to-market ratio over the last five years, mean change in return-on-assets ratio over the last five years, mean change in the firm's industry median return-on-assets ratio over the last five years, mean of the annual median percentage sales growth of all firms in the same industry as the firm over the last five years, goodwill intensity, number of years in which the firm reported write-offs in the last five years, cumulative abnormal returns over the last 12 months ending four months after the fiscal year end (to capture investors' reaction to the write-offs information in the annual report), cumulative abnormal returns over the last five years ending four months after the fiscal year end of year t-1. The main variable of interest is *Underdep* (under-depreciation scaled by average of total assets). If this variable is a good estimate of the true level of under-depreciation, then I expect a positive coefficient for β_1.

Panel B of Table 3 reports the results of Equation (4). As expected, *Underdep* is positively associated with future write-offs. The coefficient on U*nderdep* is positive and significant when the dependent variable is write-offs in year t+2 (t-statistic of 3.87), write-offs in year t+3 (t-statistic of 7.35) and change in average write-offs for next three years relative to that of the current year (t-statistic is 7.03). However, the coefficient on U*nderdep* is positive but not significant (t-statistic of 1.24) when the dependent variable is next year (t+1) write-offs. This shows that a higher level of under-depreciation in the current year is associated with increased write-downs in the future. These results are obtained even after controlling for the market's expectation of firm's future write-offs, historical firm performance, and the firm's own history of write-offs. The sign of the coefficients on all the controls are consistent with those in Hanna and Vincent (1996).

5.2 Future Earnings

Having documented the effect of under-depreciation on future write-offs, I further verify that under-depreciation is also associated with negative future earnings. I examine this relationship using the following equation:

$$Future\_Earnings_{i,t+k} = \beta_0 + \beta_1 Underdep_{i,t} + \beta_2 Earnings_{i,t} + \sum\hat{\beta}_j Controls_{i,t} + IndustryFE + YearFE + \varepsilon_{i,t+k} \quad \textit{(Eq. 5)}$$

I use four proxies for future earnings including the earnings for year t+1, t+2, and t+3, and excess future earnings computed as the difference between the average of the next three years' earnings and the current year earnings. Earnings is defined as income before extraordinary items (IB) scaled by average total assets. I control for current earnings scaled by average total assets, log of market value of equity, R&D expense scaled by average total assets, SG&A expense scaled by average total assets, leverage, current earnings growth, and an indicator for negative earnings in the current year. The main variable of interest is *Underdep* (under-depreciation scaled by average of total assets). If this variable is a good estimate of the true level of under-depreciation for the current year, then I expect a negative coefficient for β_1.

Table 4 panel B reports the results of Equation (5). The t-statistics are reported by clustering errors by industry and year. As can be seen in this table, *Underdep* is negatively associated with future earnings. In particular, the coefficient on *Underdep* is negative and significant for year t+2 (t-statistic is -5.42) and for year t+3 (t-statistics is -5.59). However, the coefficient on *Underdep* is negative but not significant (t-statistic is -1.12) for year t+1. The relationship also holds when the dependent variable is excess future earnings, computed as the difference between the average of earnings for the next three years and the current year earnings.

6. Under-depreciation and Future Stock Returns

In this section, I test whether the information contained in my measure of estimated maintenance capex is fully priced by investors. Specifically, I test the implications of under-depreciation for future stock returns.

If the estimated under-depreciation is not associated with future excess stock returns after controlling for the known determinants of the cross section of returns, then the inference could be either one of the following. First, it is possible that investors price the stocks as if the periodic capacity costs are irrelevant. Proponents of EBITDA, for example, may think that periodic capacity costs do not affect cash flows and therefore should not have any implications for valuation. Second, it could be that the information in the under-depreciation measure has already been priced. Lastly, it may suggest that my measure is not a good estimate of the true capacity cost.

On the other hand, if the under-depreciation measure is negatively correlated with future excess stock returns, then we can infer that the measure is a good estimate of the true capacity cost, and that investors do not fully price this information. To test this, I examine the following Fama-Macbeth regression:

$$Future\_Returns_{i,t+1} = \beta_0 + \beta_1 Underdep\_indadj_{i,t} + \sum \beta_j Controls_{i,t} + \varepsilon_{i,t+1} \qquad \textit{(Eq. 6)}$$

where future returns are measured in two different ways: monthly excess returns or annual excess returns. Monthly excess returns are obtained by subtracting the risk-free return from each stock's raw return. Annual buy and hold excess returns are obtained by subtracting annual buy and hold risk free return from each stock's annual buy and hold raw return. I control for log of market capitalization, log of book-to-market ratio, momentum, operating profitability, and new investment in long-term operating assets (Fama and French 2015). The main independent variable, *Underdep_indadj*, is defined as firm-level under-depreciation minus the industry median. I expect the coefficient β_1 to be negative, which would indicate that stocks with higher industry adjusted under-depreciation in the current year experience negative abnormal returns in the future.

Return tests are conducted by mapping monthly stock returns from CRSP with annual accounting data from Compustat. I map them using both annual and monthly rebalancing methods. In annual rebalancing, the monthly returns starting from May of year t to April of year t+1 are mapped to the independent variable of interest, *Underdep_indadj*, for the fiscal year ending in year t-1. The advantage of this approach is that it yields an abnormal return measure that accurately represents investor's experience. The disadvantage of this approach is that it is more sensitive to the problem of cross-sectional dependence among sample firms and a poorly specified asset pricing model (Lyon, Barber and Tsai 1999). In monthly rebalancing, each monthly return is mapped to *Underdep_indadj* for the nearest available fiscal year with a gap of four months[6]. The advantage of this approach is that it controls well for cross-sectional dependence among sample firms and is generally less sensitive to a poorly specified asset pricing model. The disadvantage of this approach is that it yields an abnormal return measure that does not precisely measure investor experience.

Table 5 reports the results from annual and monthly Fama-MacBeth cross-sectional regressions (Fama and Macbeth 1973) of individual stocks' excess returns on lagged *Underdep_indadj*. Panel A of Table 5 reports the results of annual return regression where the dependent variable is the buy and hold excess returns accumulated from the month of May of year t to April of year t+1. For each return year, the buy and hold excess returns is mapped to the independent variable of interest, *Underdep_indadj*, for the fiscal year ending in year t-1. The coefficient on *Underdep_indadj* is negative and significant (t-statistic is -3.71) after controlling for size, book-to-market, operating profitability and investment. The point estimate on *Underdep_indadj* range from -0.439 (without controls) to -0.368 (with controls).

[6] I assume that accounting data is publicly available by the end of 4th month after the fiscal year end.

Panel B of Table 5 reports the results of monthly return regression where the dependent variable is the monthly excess return. The independent variable, *Underdep_indadj*, is updated only once a year in the month of April using the data for the fiscal year ending in year t-1. Even here, the coefficient is negative and significant. The t-statistic is -4.66 without controls and -4.40 after adding the controls. The point estimate on *Underdep_indadj* ranges from -0.035 (without controls) to -0.032 (with controls). Panel C of Table 5 reports the results of monthly return regression where the dependent variable is the monthly excess return. The independent variable, *Underdep_indadj*, is updated every month using the data from the nearest fiscal year with a gap of four months. As with the annual rebalancing approach, the monthly rebalancing approach also shows that the coefficient is negative and significant with the t-statistic of -4.36 without controls and -4.18 with controls. The point estimate on *Underdep_indadj* ranges from -0.033 (without controls) to -0.031 (with controls).

Given that my estimate of under-depreciation predicts negative future returns, I further examine whether a trading strategy of going long on highest decile portfolio and short on lowest decile portfolio of under-depreciation can generate negative returns. Specifically, every month I assign firms to deciles based on the level of *Underdep_indadj*. I then compute monthly equal-weighted (EW) and value-weighted (VW) portfolio returns for each decile portfolio for the period of May 1974 to December 2016. The zero-investment portfolio return for each calendar year is then estimated by the difference between the Jensen's alphas of the highest-ranked and lowest-ranked portfolios. Because alphas are calculated using monthly returns, they are annualized by multiplying by 12. Means and statistical significance of the zero-investment portfolio returns for each calendar year from 1974 to 2016 are presented in Table 6. Zero-investment portfolio alphas formed based on the level of industry adjusted under-depreciation are negative for more than 70% of the years (not tabulated). Table 6 Panel A reports the average annualized zero-investment portfolio returns, where portfolios are assigned using annual rebalancing method. The average values of equal-weighted (value-weighted) raw returns are -4.38% (-3.60%). The average values of equal-weighted (value-weighted) alphas are -3.97% (-3.35%) and -3.72% (-2.89%) in the Carhart four factor model and the Fama and French five factor model, respectively. All these returns are statistically significant at 1% level with absolute value of t-statistics above 3. Table 6 Panel B reports similar results when portfolios are assigned using monthly rebalancing method. The average values of equal-weighted (value-weighted) raw returns are -4.36% (-3.22%). The average values of equal-weighted (value-weighted) alphas are -4.21% (-3.25%) and -4.11% (-2.77%) in the Carhart four factor model and the Fama and French five factor model, respectively. These returns are also statistically significant at 1% level with absolute value of t-statistics above 3.

Taken together, all the above results suggest that investors do not fully price the information in under-depreciation, possibly because they do not have information on the true capacity cost and how much the capacity cost differs from the reported D&A expense.

7. Implications of Maintenance CapEx for Future Investments

7.1 Under-investment and Future Investments

In this section, I examine whether my measure of maintenance capex can explain firms' future abnormal investments in long-term operating assets. Specifically, I use the construct of under-investment, measured as the difference between the estimated maintenance capex and the actual investments made by the firm in long-term operating assets, to test whether any shortfall in expenditures in the current year can predict abnormal investment expenditures in the future years.

Maintenance capex is the minimum amount of capital expenditure required to be replaced to maintain the current operations. If the firm does not invest at least to this extent, then it will be compelled to increase its investments in the future to sustain its operations. If my measure of maintenance capex is a good estimate of the actual capacity costs, then I expect firms with higher levels of under-investment to increase their future investments. I examine this implication of under-investment using the following equation:

$$Future\_Investments_{i,t+k} = \beta_0 + \beta_1 Underinvest_{i,t} + \sum \beta_j Controls_{i,t} + \varepsilon_{i,t+1} \qquad \textit{(Eq. 7)}$$

I use four proxies for future investments including investments made in year t+1, t+2, and t+3, and excess investments computed as the difference between the average of the next three years' investments and the current year investment. Here I refer to investments as the annual change in long-term operating assets, excluding any non-transaction accruals (Lewellen and Resutek 2016). I control for current investments, leverage, log of market value of equity, log of firm age, book-to-market ratio, and amount of cash (CHE) scaled by total assets. The main variable of interest is *Underinvest* (Under-investment scaled by average of total assets). If this variable is a good estimate of the level of under-investment, then I expect a positive coefficient for β_1. The positive coefficient would imply that firms must invest more in the future to compensate for the under-investment in the current period.

Panel B of Table 7 reports the results of equation 6. The t-statistics are reported by clustering errors by industry and year. As can be seen in this table, *Underinvest* is positively associated with future investments. In particular, the coefficient on *Underinvest* is positive and significant when the dependent variable is investment in year t+1 (t-statistic is 12.03), investment in year t+2 (t-statistic is 8.58) and investments in year t+3 (t-statistic is 6.70). The relationship also holds when the dependent variable is excess future investments, computed as the difference between the average investment over the next three years and the current year investment. For robustness, I also check whether this relationship holds when the dependent variables are replaced by abnormal investment. For each future year, abnormal investment is computed as the difference between the investment in that year and the average investment over the last three years (Titman et al., 2004). Panel C of Table 7 reports the results. The coefficient on *Underinvest* continues to be positive and significant when the dependent variable is abnormal investment in year t+1 (t-statistics is 8.85), abnormal investment in year t+2 (t-statistics is 11.89), and abnormal investment in year t+3 (t-statistics is 8.58). These results are consistent with the idea that if firms under-invest relative to the estimated maintenance capex in the current year, then they will have to increase their investments in future to sustain their current operations.

7.2 Re-examining the Relationship Between Investment & Future Stock Returns

In this section, I examine whether the estimated maintenance capex measure can partially explain the negative relationship between investment and future stock returns reported in prior literature.

The information content of long-term assets on the balance sheet and its implications for future stock has been extensively studied in both the finance and accounting literatures. The finance literature focuses on the additions to the long-term asset portfolio through capital investments. Several empirical studies in this literature show a significantly negative relationship between capital investment (and asset growth) and future abnormal stock returns, which is popularly known as the investment anomaly. Cooper et al. (2008) show that corporate events related with asset expansion tend to be followed by periods of abnormally low returns. Researchers have tried to explain this relationship using both behavioral and risk-based explanations. Titman et al. (2004) suggest that investors do not fully understand managers' bias towards empire building and hence overreact to the investment decision. The negative future abnormal return is then a correction to the initial overreaction. While the behavioral explanation suggests market mispricing, the risk-based explanation suggests a reduction in expected returns following the resolution of uncertainty in investment. This explanation is derived from real-options models, which predict a decline in systematic risk following the exercise of growth options. Consistent with this explanation, Cooper and Priestley (2011) show that firms' systematic risk falls during periods of high investment (asset growth). Prior accounting studies also examine this section of the balance sheet as long-term operating accruals and found similar implications for future abnormal returns. Fairfield and Whisenant (2003) argue that both conservative accounting principles and diminishing marginal returns to increased investment tend to reduce future profitability.

While I do not contest the above explanations, I posit that the negative relationship between investment and future stock returns can partly be explained by the inability of investors to understand how much of the current investment is for maintenance and how much of it is for growth. I test this hypothesis using the following equation.

$$Future\_Returns_{i,t+1} = \beta_0 + \beta_1 Invacc_{i,t} + \beta_1 Mcap_{i,t} + \beta_1 Invacc_{i,t} * Mcap_{i,t} + \sum \beta_j Controls_{i,t} + \varepsilon_{i,t+1} \quad \textit{(Eq. 8)}$$

where future returns are monthly excess returns measured by subtracting risk-free return from the stocks' raw returns. I control for other important determinants of the cross-section of returns.

This includes log of market capitalization, log of book to market ratio, momentum, and operating profitability. *Mcap* is the estimated maintenance capex scaled by average total assets and *Invacc* is the total new investment added to long-term operating assets in the current year scaled by average total assets.

Table 8 reports the results from monthly Fama-MacBeth cross-sectional regressions. Panel A of Table 8 reports the results using annual rebalancing, where financial statement variables are only updated once a year and Panel B of Table 8 reports the results using monthly rebalancing, where financial statement variables are updated as and when they are available to the investor (four months from the fiscal year end). Column (1) in both the panels is the baseline regression to replicate the negative relationship between investment and future stock returns. Consistent with prior literature, the coefficient (-0.012) on investment is negative and significant (t-statistic of -5.80). In column (2), I interact investment with the reported D&A expense. The coefficient on the interaction term is negative and significant at the 10% level. This shows that the negative relationship between investment and future stock returns is more pronounced at higher levels of D&A expense. In column (3), I interact investments with the estimated maintenance capex. The coefficient on the interaction term is negative and significant at the 5% level, indicating that the negative relationship of investment and future stock returns is also more pronounced at higher levels of maintenance capex. Moreover, the coefficient in column (3) is -0.158, which is much lower than the one in column (2) (-0.083). These results suggest that investors do not price current investments after adjusting for the required maintenance capex.

8. Conclusion

The rate of technological development is rapidly increasing and is proving to be particularly costly for businesses today. It is crucial that firms recognize the need to replace technologically obsolete assets, record the related expense in a timely manner, and invest accordingly to remain competitive. Ideally, managers should anticipate the capacity costs of long-term operating assets due to technological obsolescence and incorporate that into D&A expense to match with the related revenue generated. In reality, however, firms often record D&A expense that do not capture the effect of technological changes. Such practice understates the actual capacity cost required for a firm to sustain its current level of revenue and may give investors the false impression that the firm could sustain its current level of profitability in the future.

In this paper, I propose a measure of maintenance capex that reflects the true capacity cost required for a firm to sustain its current level of revenue. My measure has three features that makes it a better estimate of capacity cost than the traditional D&A expense. First, it captures not only the periodic wear and tear cost, but also the costs arising from the technological obsolescence of long-term operating assets. Second, it takes into account the fact that the relationship between capacity costs and sales varies by industry. Third, it incorporates the effect of firm characteristics, such as a firm's asset composition, cost structure, and life cycle, on the relationship between capacity costs and sales. Using this measure, I identify under-depreciating firms that record D&A expenses which are lower than maintenance capex.

I validate my measure by showing that under-depreciation is associated with future write-offs and hence negative future earnings. In other words, if a firm does not recognize sufficient D&A expense in the current period, it will ultimately have to record a write-off of the technologically obsolete assets in some future period. The asset write-off will have a negative impact on the firm's future earnings. My measure can help investors anticipate future write-offs and negative future earnings.

Moreover, I show that under-depreciation is associated with significantly negative future stock returns. This confirms my hypothesis that investors may not realize that a firm's earnings are overstated when the firm fails to recognize the costs of technological obsolescence in its D&A expense. Investors seem to have priced the stock assuming that the firm can sustain the same level of earnings without incurring the related capacity costs and are negatively surprised in the future period.

An alternative way to interpret the estimated capacity cost is that it proxies for the minimum amount of capital expenditure required for a firm to replace outdated assets and remain competitive. When compared to the actual amount of investment made by a firm, one can draw inferences on whether the firm has invested enough to sustain its current revenue. One can also observe the amount of actual investment in excess of the required investment, which can lead to revenue growth beyond the current level. In additional tests, I show that under-investment is positively associated with future investments. In other words, if a firm does not make sufficient investments in the current period, it will have to increase its investment in the future period. I also re-examine the negative relationship between asset growth and future stock return documented in prior literature and find that this relationship is partly caused by investors' inability to differentiate maintenance versus growth capex.

In conclusion, my measure of maintenance capex can inform financial statement users about the actual capacity cost required to sustain a firm's current revenue and help them identify under-depreciating firms that are likely to have future asset write-downs. It also enables investors to distinguish between investments that are necessary to sustain a firm's current level of profitability versus the investments that could result in further expansion of a business.

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Appendix: Variable names and definitions

Variables	Formula/Definition
Model Variables	
Capcost_5y	Capcost_5y is the sum of annual capacity costs for the last five years (t-4 to t) scaled by average total assets of year t. Annual Capacity Costs = Depreciation & Amortization expense [DP>0]+ Goodwill impairment [-(GDWLIP<0)] + Asset write-downs [-(WDP<0)] + loss on sale of assets [-(GLP<0)] + Other special items[7] [-((SPI-sum(AQP,GLP,GDWLIP,SETP,RCP,WDP,DTEP,RDIP,SPIOP,0))<0)].
Sales_5y	Sales_5y is the sum of annual sales (SALE) for the last five years (t-4 to t) scaled by average total assets in year t.
Dol_5y	Dol_5y is the average operating leverage over the last five years (t-4 to t). Following Aboody, Levi and Weiss (2018), I estimate the following time series model for each firm i and year t. $OC_{i,k} = \beta_0 + \beta_1 REV_{i,k} + \varepsilon_{i,k}, k = t-4, \ldots, t$ where OC is the natural logarithm of total operating costs, estimated as revenue (SALE) minus income from operations (IB). REV is the natural logarithm of revenue (SALE). Operating leverage (t)=$1-\beta_1$.
Age_5y	Age_5y is the average of firm age over the last five years (t-4 to t). Firm age is measured as number of years from the first year in which firm data are available in Compustat.
Opl_intst_5y	Opl_intst_5y is the average of operating lease intensity measured over the last five years (t-4 to t). Operating lease intensity is measured by the ratio of present value of operating leases divided by the sum of present value of operating leases and total assets (AT).
Gdw_intst_5y	Gdw_intst_5y is the average of goodwill intensity measured over the last five years (t-4 to t). Goodwill intensity is measured as the ratio of goodwill (GDWL) to total assets (AT).
Sga_intst_5y	Sga_intst_5y is the average of SG&A intensity measured over the last five years (t-4 to t). SG&A intensity is measured as the ratio of SG&A expense (XSGA) to total operating costs (SALE-IB).
Size_5y	Size_5y is the average of firm size measured over the last five years (t-4 to t). Firm size is computed as the natural logarithm of market value of equity (CSHO*PRCC_F).
Capcost_ratio	Capcost_5y divided by Sales_5y.

[7] Only the part of special items (SPI) related to asset write-downs.

Model Output	
Mcap	Maintenance capex for the current year that supports current operations. I first estimate the following regression by industry and year: $$Capcost\_5y_{i,t} = \beta_{0,Ind,t} + \beta_{1,Ind,t}Sales\_5y_{i,t} + \sum\beta_{j,Ind,t}Controls_{i,t} + \sum\beta_{k,Ind,t}Sales\_5y_{i,t} * Controls_{i,t} + \varepsilon_{i,t}$$, where i denotes the firm, Ind denotes the industry, and t denotes the year. Industry is defined using the Fama and French 48-industry classification. I then calculate the maintenance capex as follows: $$Maintenance\ capex_{i,t} = \left(\frac{\widehat{Capcost}\_5y_{i,t}}{Sales\_5y_{i,t}}\right) * Sales_{i,t}$$, where $$\widehat{Capcost}\_5y_{i,t} = \hat{\beta}_{0,Ind,t} + \hat{\beta}_{1,Ind,t}Sales\_5y_{i,t} + \sum\hat{\beta}_{j,Ind,t}Controls_{i,t} + \sum\hat{\beta}_{k,Ind,t}Sales\_5y_{i,t} * Controls_{i,t}$$
Mcap_ratio	Maintenance capex (Mcap) divided by current sales (SALE).
Dp_ratio	Sum of depreciation & amortization expense (DP) for the last five years divided by Sales_5y.
Underdep_ratio	The difference between maintenance capex (Mcap) and depreciation & amortization expense (DP) divided by sales (SALE).
Underdep	The difference between maintenance capex (Mcap) and depreciation & amortization expense (DP) divided by average total assets (AT).
Underinvest	The difference between maintenance capex (Mcap) and investments divided by average total assets (AT). Investments is computed as the difference between change in long-term net operating assets and total non-transaction accruals, scaled by average total assets (Lewellen and Resutek 2016).

Variables for Earnings Regression	
Earnings	Income before extraordinary items (IB) scaled by average total assets (AT).
Future_earnings	Change in future earnings, measured by the average of the next three year's earnings (t+1, t+2, t+3) minus current earnings (t). Earnings is measured as income before extraordinary items (IB) scaled by average total assets (AT).
Logmve	Natural logarithm of market value of equity (CSHO*PRCC_F).
R&D	R&D expenditure (XRD+RDIP) scaled by total assets (AT).
SG&A	SG&A expenditure (XSGA) scaled by total assets (AT).
Leverage	Total debt (DLTT+DLC) divided by market value of equity (CSHO*PRCC_F).
Earnings_growth	Percent change in the current year's earnings from the previous year. Earnings is measured as income before extraordinary items (IB) scaled by average total assets (AT).
Loss_dummy	Dummy variable that takes the value of 1 if earnings is negative and 0 otherwise.

Variables for Write-off Regression	
Write-off	Goodwill impairment [-(GDWLIP<0)] + Asset write-downs [-(WDP<0)] + loss on sale of assets [-(GLP<0)] + Other special items [-((SPI-sum(AQP,GLP,GDWLIP,SETP,RCP,WDP,DTEP,RDIP,SPIOP,0))<0)] scaled by average total assets (AT). Firm-years with missing values for Write-offs are coded as 0.
Excess Future_writeoff	Change in future write-offs, measured by average of the next three year's Write-off (t+1, t+2, t+3) minus current Write-off (t). Write-off is defined above.
Logsale	Natural logarithm of sales (SALE).
BTM_adj	Book-to-market ratio minus the industry median measured at the end of year (t). Book-to-market ratio is measured as book value of equity [AT – LT + TXDITC - preferred stock (first available value of PSTKRV, PSTKL, PSTK)] divided by market value of equity.
Ch_BTM	Average of the year-over-year changes in book-to-market ratio over the last five years.
Ch_ROA	Average of the year-over-year changes in return-on-assets ratio over the last five years. ROA is measured as income before extraordinary items (IB) divided by average total assets (AT).
Ch_BTM_median	Average of the year-over-year changes in a firm's industry median book-to-market ratio over the last five years.
Ch_ROA_median	Average of the year-over-year changes in a firm's industry median return-on-assets ratio over the last five years.
Ch_sgrth_median	Average of the year-over-year changes in a firm's industry median sales growth over the last five years.
Hist_firm	Number of years in which the firm reported write-offs in the last five years.
Gdw_intst	Goodwill (GDWL) scaled by total assets (AT).
Bhar_tm2tm1	Buy-and-hold abnormal returns over the last 12 months ending four months after the current fiscal year end.
Bhar_tm5tm2	Buy-and-hold abnormal returns over the last five years ending four months after the fiscal year end of year t-1.

Variables for Investment Regression	
Invst	The difference between change in long-term net operating assets and total non-transaction accruals, scaled by average total assets (Lewellen and Resutek 2016). This captures the amount of new investment added to long-term operating assets on the balance sheet in a year. Non-transaction accruals are defined by the sum of depreciation & amortization expense (DPC), deferred taxes (TXDC), equity in net loss of unconsolidated subsidiaries (ESUBC), loss (gain) on sale of property, plant and equipment and investments (SPPIV), funds from operations-other (including accruals related to special items) (FOPO), extraordinary items and discontinued operations (XIDOC-XIDO).
Future_invst	Change in future investments, measured by average of the next three year's invst (t+1, t+2, t+3) minus current year invst (t).

Abinvst	Abnormal investments, measured by current year invst minus the average of the last three year's invst.
Leverage	Total debt (DLTT+DLC) to market value of equity (CSHO*PRCC_F).
Logmve	Natural logarithm of market value of equity.
Logage	Natural logarithm of firm age, which is computed as years from the first year in which firm data are available in Compustat.
Cash_stock	Cash & Cash equivalents (CHE) divided by total assets (AT).
BTM	Book value of equity [AT-LT+TXDITC-preferred stock (first available value of PSTKRV, PSTKL, PSTK)] divided by market value of equity.

Table 1: Descriptive Statistics of Model Variables

This table presents descriptive statistics for the variables used in the model to estimate maintenance capex. The sample period is from 1974 to 2016. All the variables are defined in the appendix. Panel A reports the descriptive statistics for the full sample. Panel B reports the time trend in these variables and Panel C reports the time series average of yearly cross sectional mean values of the variables for Fama French 48 industries. Panel D reports the univariate and multivariate regression of Capcost_ratio on firm characteristics. Year and Industry fixed effects are included and t-statistics using robust standard errors that are clustered at year and industry level are presented in parentheses below coefficient estimates. All continuous variables are winsorized annually at their 1st and 99th percentiles. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

Panel A: Full Sample

	N	Mean	Std dev	First quartile	Median	Third quartile
Capcost_ratio	109252	0.07	0.09	0.02	0.04	0.07
Dol_5y	109252	0.07	0.22	-0.03	0.03	0.14
Age_5y	109252	18.21	12.5	8	15	25
Opl_intst_5y	109252	0.06	0.09	0.01	0.03	0.07
Gdw_intst_5y	109252	0.05	0.1	0	0	0.05
Sga_intst_5y	109252	0.22	0.17	0.1	0.19	0.31

Panel B: Time Trend from 1974 to 2016

Year	Capcost_ratio	Dol_5y	Age_5y	Opl_intst_5y	Gdw_intst_5y	Sga_intst_5y
1974	0.04	-0.01	12.31	0.01	0.00	0.17
1975	0.04	0.00	12.72	0.02	0.00	0.17
1976	0.04	0.00	13.15	0.03	0.00	0.17
1977	0.04	0.01	13.77	0.04	0.00	0.17
1978	0.04	0.02	13.96	0.04	0.00	0.17
1979	0.04	0.02	14.58	0.04	0.00	0.17
1980	0.04	0.02	15.21	0.04	0.00	0.17
1981	0.04	0.02	15.91	0.04	0.00	0.18
1982	0.04	0.01	16.66	0.04	0.00	0.18
1983	0.04	0.02	17.10	0.04	0.00	0.19
1984	0.04	0.03	17.26	0.04	0.00	0.19
1985	0.05	0.04	17.71	0.05	0.00	0.20
1986	0.05	0.06	17.09	0.05	0.00	0.21
1987	0.05	0.07	17.16	0.05	0.00	0.21
1988	0.06	0.06	17.41	0.06	0.01	0.21
1989	0.06	0.06	17.01	0.06	0.01	0.21
1990	0.06	0.05	17.24	0.06	0.02	0.21
1991	0.06	0.04	17.53	0.06	0.02	0.21
1992	0.06	0.04	17.91	0.06	0.03	0.21

1993	0.07	0.05	18.01	0.06	0.03	0.21
1994	0.07	0.06	18.00	0.06	0.04	0.22
1995	0.07	0.08	17.73	0.06	0.04	0.22
1996	0.07	0.10	17.45	0.06	0.04	0.22
1997	0.07	0.09	17.39	0.06	0.04	0.22
1998	0.07	0.09	17.52	0.07	0.05	0.22
1999	0.08	0.10	16.48	0.07	0.05	0.24
2000	0.08	0.09	17.13	0.07	0.05	0.24
2001	0.09	0.08	17.93	0.08	0.06	0.24
2002	0.10	0.08	18.11	0.08	0.07	0.25
2003	0.11	0.09	18.27	0.08	0.08	0.26
2004	0.10	0.10	19.16	0.08	0.09	0.26
2005	0.09	0.11	19.96	0.08	0.10	0.25
2006	0.07	0.13	20.54	0.08	0.11	0.25
2007	0.07	0.12	20.91	0.08	0.12	0.25
2008	0.07	0.10	22.12	0.07	0.12	0.24
2009	0.08	0.10	22.28	0.07	0.12	0.25
2010	0.08	0.10	22.80	0.07	0.12	0.24
2011	0.08	0.11	23.71	0.07	0.12	0.24
2012	0.08	0.12	24.24	0.07	0.12	0.24
2013	0.08	0.13	24.59	0.07	0.12	0.25
2014	0.07	0.14	24.94	0.07	0.13	0.25
2015	0.08	0.14	25.36	0.07	0.13	0.25
2016	0.08	0.14	25.47	0.07	0.14	0.25

Panel C: Industry Averages Using Fama and French 48-Industry Classification

Name	**Capcost_ ratio**	**Dol_ 5y**	**Age_ 5y**	**Opl_intst_ 5y**	**Gdw_intst _5y**	**Sga_intst_ 5y**
Agriculture	0.06	0.07	16.78	0.04	0.05	0.15
Food Products	0.03	0.03	23.10	0.03	0.06	0.19
Candy & Soda	0.03	-0.02	16.92	0.03	0.00	0.28
Beer & Liquor	0.05	0.00	20.09	0.02	0.02	0.25
Tobacco Products	0.02	-0.05	19.61	0.01	0.00	0.22
Recreation	0.04	0.07	17.12	0.04	0.04	0.28
Entertainment	0.10	0.10	14.58	0.07	0.05	0.17
Printing and Publishing	0.06	0.05	22.61	0.05	0.11	0.32
Consumer Goods	0.03	0.05	22.39	0.05	0.05	0.30
Apparel	0.02	0.05	19.66	0.09	0.04	0.25
Healthcare	0.06	0.05	11.43	0.09	0.11	0.17
Medical Equipment	0.06	0.10	14.47	0.04	0.06	0.40

Pharmaceutical Products	0.08	0.21	15.88	0.04	0.03	0.38
Chemicals	0.05	0.06	23.49	0.03	0.05	0.20
Rubber and Plastic Products	0.05	0.04	18.18	0.04	0.06	0.19
Textiles	0.04	0.04	19.62	0.04	0.04	0.15
Construction Materials	0.04	0.07	22.40	0.03	0.05	0.17
Construction	0.03	0.05	17.88	0.03	0.04	0.11
Steel Works Etc.	0.04	0.11	22.04	0.01	0.04	0.10
Fabricated Products	0.04	0.04	19.28	0.02	0.05	0.14
Machinery	0.04	0.09	21.00	0.03	0.06	0.23
Electrical Equipment	0.04	0.08	21.09	0.03	0.06	0.24
Automobiles and Trucks	0.04	0.05	22.17	0.02	0.05	0.14
Aircraft	0.04	0.09	29.18	0.03	0.08	0.14
Shipbuilding, Railroad Equipment	0.04	0.02	17.00	0.02	0.03	0.10
Precious Metals	0.21	0.20	16.74	0.01	0.00	0.17
Non-Metallic & Metal Mining	0.09	0.16	19.88	0.02	0.02	0.11
Coal	0.10	0.13	11.64	0.02	0.01	0.07
Petroleum and Natural Gas	0.19	0.14	17.81	0.02	0.01	0.13
Utilities	0.09	-0.06	31.56	0.00	0.00	0.01
Communication	0.17	0.04	15.43	0.04	0.06	0.21
Personal Services	0.07	0.02	15.30	0.13	0.08	0.24
Business Services	0.08	0.08	12.51	0.09	0.09	0.29
Computers	0.07	0.10	14.04	0.06	0.06	0.35
Electronic Equipment	0.07	0.12	16.82	0.04	0.04	0.27
Measuring and Control Equipment	0.05	0.11	18.25	0.04	0.06	0.35
Business Supplies	0.05	0.05	24.16	0.03	0.05	0.18
Shipping Containers	0.05	0.03	21.10	0.02	0.07	0.12
Transportation	0.07	0.04	18.31	0.10	0.03	0.08
Wholesale	0.02	0.04	16.97	0.05	0.05	0.18
Retail	0.03	0.03	16.98	0.19	0.04	0.26
Restaurants, Hotels, Motels	0.06	0.03	15.65	0.18	0.03	0.13

Panel D: Capcost_ratio vs Firm Characteristics

	Dependent variable: Capcost_ratio					
Intercept	0.062***	0.097***	0.068***	0.066***	0.059***	0.089***
	(109.75)	(10.29)	(56.03)	(101.60)	(12.96)	(9.20)
Dol_5y	0.051***					0.044***
	(6.44)					(6.56)
Age_5y		-0.012***				-0.010***
		(-3.30)				(-3.08)
Opl_intst_5y			-0.051**			-0.063***
			(-2.37)			(-2.78)
Gdw_intst_5y				-0.015		-0.006
				(-0.92)		(-0.40)
Sga_intst_5y					0.030	0.020
					(1.42)	(1.12)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R-squared	0.279	0.274	0.266	0.265	0.267	0.288
N	109252	109252	109252	109252	109252	109252

Table 2: Descriptive Statistics of Model Output

This table presents descriptive statistics for estimated maintenance capex as a ratio of sales (Mcap_ratio), and under depreciation as a ratio of sales (Underdep_ratio). Under depreciation is measured as the difference between maintenance capex and depreciation & amortization (D&A) expense. Underdep (%) is the difference between estimated maintenance capex and D&A expense divided by D&A expense. This measures the extent of under depreciation comparing the capacity costs possibly incurred by the firm and what is being reported in terms of D&A expense. For comparison, the table also provides descriptive statistics of Capcost_ratio and Dp_ratio. The sample period is from 1974 to 2016. All the variables are defined in the appendix. Panel A reports the descriptive statistics for the full sample. Panel B reports time series average of yearly cross sectional mean and median values of the variables for small, medium, and large size groups classified using NYSE size breakpoints. Panel C reports the time trend in these variables and Panel D reports the time series average of yearly cross sectional mean values of the variables for Fama French 48 industries.

Panel A: Descriptive Statistics

	N	Mean	Std dev	First quartile	Median	Third quartile
Capcost_ratio	109252	0.065	0.087	0.023	0.040	0.073
Dp_ratio	109252	0.053	0.063	0.020	0.034	0.060
Mcap_ratio	109252	0.067	0.073	0.028	0.045	0.075
Underdep_ratio	109252	0.013	0.050	-0.003	0.007	0.022
Underdep (%)	109252	0.645	1.404	-0.085	0.251	0.825

Panel B: Descriptive Statistics by Size Group

Size	Capcost_ratio		Dp_ratio		Mcap_ratio		Underdep_ratio		Underdep (%)	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Small	0.061	0.038	0.047	0.031	0.059	0.043	0.011	0.009	0.740	0.322
Medium	0.067	0.042	0.056	0.037	0.070	0.049	0.012	0.009	0.588	0.260
Large	0.070	0.049	0.062	0.043	0.076	0.054	0.012	0.008	0.455	0.196

Panel C: Time Trend from 1974 to 2016

Year	Capcost_ratio		Dp_ratio		Mcap_ratio		Underdep_ratio		Underdep (%)	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
1974	0.038	0.026	0.037	0.025	0.038	0.027	0.004	0.003	0.327	0.155
1975	0.037	0.025	0.036	0.024	0.038	0.027	0.002	0.002	0.272	0.111
1976	0.036	0.025	0.035	0.024	0.037	0.027	0.002	0.003	0.295	0.123
1977	0.036	0.024	0.034	0.023	0.036	0.027	0.002	0.003	0.304	0.133
1978	0.036	0.024	0.034	0.023	0.036	0.027	0.002	0.003	0.318	0.119
1979	0.036	0.024	0.034	0.023	0.036	0.027	0.002	0.003	0.321	0.120
1980	0.035	0.024	0.034	0.023	0.036	0.026	0.001	0.002	0.285	0.102
1981	0.036	0.025	0.035	0.024	0.037	0.027	0.000	0.002	0.232	0.076
1982	0.038	0.026	0.036	0.025	0.038	0.028	-0.003	0.000	0.153	0.010

1983	0.039	0.027	0.037	0.026	0.040	0.030	-0.003	0.000	0.204	0.013
1984	0.041	0.029	0.039	0.028	0.042	0.032	0.000	0.002	0.277	0.088
1985	0.045	0.032	0.041	0.029	0.046	0.036	0.000	0.003	0.289	0.104
1986	0.050	0.035	0.044	0.031	0.051	0.040	0.001	0.003	0.351	0.116
1987	0.053	0.036	0.046	0.032	0.054	0.042	0.005	0.005	0.430	0.156
1988	0.056	0.038	0.048	0.033	0.057	0.044	0.007	0.006	0.503	0.224
1989	0.061	0.040	0.052	0.035	0.062	0.044	0.010	0.008	0.527	0.264
1990	0.062	0.041	0.053	0.035	0.062	0.045	0.009	0.007	0.479	0.221
1991	0.062	0.043	0.052	0.036	0.062	0.047	0.007	0.006	0.473	0.201
1992	0.064	0.043	0.053	0.036	0.064	0.049	0.009	0.008	0.539	0.238
1993	0.066	0.046	0.052	0.037	0.066	0.051	0.012	0.011	0.654	0.327
1994	0.067	0.047	0.053	0.038	0.067	0.052	0.014	0.012	0.711	0.349
1995	0.070	0.047	0.054	0.037	0.070	0.052	0.016	0.012	0.776	0.371
1996	0.072	0.048	0.056	0.038	0.072	0.054	0.017	0.012	0.773	0.392
1997	0.074	0.049	0.056	0.038	0.075	0.055	0.018	0.012	0.804	0.392
1998	0.072	0.048	0.054	0.037	0.074	0.055	0.014	0.011	0.786	0.362
1999	0.076	0.051	0.058	0.039	0.078	0.058	0.016	0.012	0.766	0.370
2000	0.082	0.053	0.063	0.041	0.084	0.059	0.018	0.012	0.765	0.359
2001	0.091	0.054	0.068	0.043	0.094	0.060	0.015	0.011	0.689	0.295
2002	0.102	0.056	0.072	0.045	0.106	0.061	0.036	0.016	1.072	0.472
2003	0.106	0.056	0.074	0.045	0.111	0.063	0.045	0.019	1.372	0.547
2004	0.097	0.052	0.070	0.044	0.098	0.063	0.041	0.019	1.528	0.639
2005	0.090	0.049	0.067	0.042	0.091	0.058	0.036	0.017	1.347	0.579
2006	0.074	0.044	0.060	0.039	0.075	0.052	0.021	0.013	1.004	0.460
2007	0.070	0.043	0.060	0.038	0.071	0.051	0.013	0.010	0.735	0.314
2008	0.074	0.045	0.057	0.038	0.076	0.054	0.017	0.012	0.759	0.366
2009	0.081	0.049	0.061	0.039	0.083	0.059	0.013	0.010	0.699	0.280
2010	0.083	0.049	0.063	0.040	0.087	0.060	0.023	0.014	0.899	0.400
2011	0.084	0.050	0.064	0.041	0.086	0.060	0.024	0.016	0.985	0.466
2012	0.084	0.051	0.065	0.041	0.087	0.062	0.020	0.015	0.930	0.440
2013	0.079	0.049	0.067	0.042	0.082	0.056	0.013	0.010	0.765	0.276
2014	0.074	0.046	0.065	0.040	0.077	0.053	0.009	0.008	0.618	0.216
2015	0.077	0.047	0.066	0.042	0.079	0.055	0.002	0.006	0.563	0.175
2016	0.079	0.050	0.069	0.043	0.081	0.055	0.001	0.006	0.545	0.172

Panel D: Industry Averages Using Fama and French 48-Industry Classification										
Industry	**Capcost_ratio**		**Dp_ratio**		**Mcap_ratio**		**Underdep_ratio**		**Underdep (%)**	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Agriculture	0.059	0.046	0.048	0.037	0.058	0.047	0.009	0.006	0.354	0.152
Food Products	0.033	0.029	0.029	0.026	0.033	0.031	0.004	0.004	0.304	0.172
Candy & Soda	0.029	0.028	0.029	0.027	0.029	0.027	0.001	0.000	0.074	0.011
Beer & Liquor	0.046	0.041	0.040	0.039	0.046	0.042	0.005	0.003	0.247	0.071
Tobacco Products	0.020	0.020	0.019	0.018	0.021	0.020	0.002	0.001	0.211	0.076
Recreation	0.038	0.030	0.029	0.026	0.039	0.036	0.009	0.009	0.715	0.339
Entertainment	0.102	0.078	0.084	0.068	0.104	0.091	0.016	0.020	0.692	0.326
Printing and Publishing	0.065	0.049	0.048	0.042	0.066	0.056	0.016	0.012	0.556	0.299
Consumer Goods	0.034	0.027	0.028	0.024	0.034	0.032	0.005	0.007	0.553	0.266
Apparel	0.024	0.020	0.018	0.017	0.024	0.023	0.005	0.006	0.632	0.354
Healthcare	0.058	0.046	0.045	0.039	0.058	0.053	0.013	0.014	0.727	0.388
Medical Equipment	0.055	0.043	0.042	0.036	0.055	0.050	0.014	0.014	0.665	0.380
Pharmaceutical Products	0.085	0.054	0.060	0.043	0.091	0.064	0.032	0.020	0.943	0.475
Chemicals	0.052	0.044	0.044	0.039	0.053	0.047	0.008	0.007	0.374	0.176
Rubber and Plastic Products	0.046	0.041	0.039	0.036	0.046	0.044	0.007	0.007	0.320	0.193
Textiles	0.042	0.038	0.033	0.031	0.042	0.039	0.007	0.006	0.406	0.188
Construction Materials	0.044	0.037	0.038	0.033	0.045	0.039	0.006	0.006	0.411	0.207
Construction	0.028	0.018	0.022	0.014	0.029	0.025	0.006	0.008	1.591	0.635
Steel Works Etc	0.044	0.039	0.036	0.033	0.044	0.041	0.007	0.006	0.406	0.224
Fabricated Products	0.040	0.033	0.032	0.029	0.040	0.036	0.007	0.005	0.301	0.184
Machinery	0.042	0.033	0.034	0.029	0.042	0.038	0.007	0.008	0.469	0.286
Electrical Equipment	0.043	0.033	0.035	0.029	0.043	0.037	0.008	0.007	0.404	0.245
Automobiles and Trucks	0.035	0.032	0.030	0.029	0.036	0.034	0.005	0.004	0.394	0.176
Aircraft	0.036	0.034	0.030	0.030	0.036	0.035	0.005	0.004	0.261	0.133
Shipbuilding, Railroad Equipment	0.037	0.022	0.036	0.022	0.034	0.021	0.008	0.004	0.401	0.183
Precious Metals	0.208	0.186	0.182	0.161	0.200	0.185	0.011	0.001	0.132	0.005

Non-Metallic & Metal Mining	0.090	0.080	0.079	0.071	0.090	0.082	0.005	0.003	0.186	0.062
Coal	0.101	0.092	0.089	0.089	0.100	0.092	-0.001	-0.006	0.005	-0.057
Petroleum and Natural Gas	0.194	0.184	0.179	0.170	0.199	0.190	0.008	0.013	0.368	0.119
Utilities	0.085	0.082	0.079	0.078	0.088	0.083	0.006	0.006	0.174	0.086
Communication	0.166	0.155	0.139	0.137	0.168	0.158	0.029	0.028	0.768	0.256
Personal Services	0.074	0.051	0.063	0.043	0.078	0.059	0.012	0.012	0.638	0.292
Business Services	0.080	0.048	0.061	0.039	0.082	0.067	0.022	0.022	1.095	0.594
Computers	0.068	0.049	0.050	0.040	0.068	0.061	0.018	0.019	0.913	0.560
Electronic Equipment	0.069	0.048	0.050	0.040	0.069	0.061	0.017	0.019	0.852	0.496
Measuring and Control Equipment	0.050	0.039	0.039	0.034	0.050	0.046	0.010	0.011	0.539	0.302
Business Supplies	0.048	0.043	0.042	0.038	0.049	0.044	0.006	0.006	0.269	0.157
Shipping Containers	0.051	0.045	0.045	0.041	0.051	0.047	0.005	0.003	0.163	0.069
Transportation	0.074	0.065	0.066	0.061	0.080	0.063	0.013	0.008	0.469	0.183
Wholesale	0.023	0.013	0.018	0.011	0.022	0.017	0.004	0.005	0.995	0.521
Retail	0.025	0.021	0.021	0.018	0.025	0.024	0.003	0.004	0.440	0.202
Restaurants, Hotels, Motels	0.058	0.050	0.049	0.044	0.058	0.051	0.007	0.007	0.280	0.148

Table 3: Under-depreciation and Future Write-offs

This table presents the results of tobit regression of *Underdep* (Under depreciation scaled by average total assets) on future write-Offs. Write-offs refer to long-term asset write-downs (tangible assets), impairments (intangible assets and goodwill) and any loss incurred on sale of these assets. Panel A reports the descriptive statistics of the variables used in this regression. These variables are defined in the appendix. Panel B reports the results of the tobit regression. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively. All continuous variables are winsorized annually at their 1st and 99th percentiles.

Panel A: Descriptive Statistics

	N	Mean	Std dev	First quartile	Median	Third quartile
Underdep	87949	0.011	0.03	-0.004	0.009	0.025
Write-off (t+1)	83785	0.009	0.032	0	0	0
Write-off (t+2)	79434	0.009	0.032	0	0	0
Write-off (t+3)	75065	0.009	0.032	0	0	0
Future_writeoff	75065	0.002	0.032	0	0	0.004
Write-off	87949	0.008	0.029	0	0	0
Logsale	87949	5.866	1.85	4.455	5.765	7.147
BTM_adj	87949	0.192	0.582	-0.143	0.068	0.386
Ch_BTM	87949	0.006	0.156	-0.054	0.004	0.066
Ch_ROA	87949	-0.001	0.026	-0.01	-0.001	0.006
Ch_BTM_median	87949	-0.009	0.071	-0.044	-0.014	0.024
Ch_ROA_median	87949	-0.001	0.009	-0.004	0	0.003
Ch_sgrth_median	87949	-0.002	0.022	-0.012	-0.002	0.009
Hist_firm	87949	0.609	0.894	0	0	1
Gdw_intst	87949	0.057	0.112	0	0	0.062
Bhar_tm2tm1	87949	0.078	0.686	-0.239	-0.022	0.229
Bhar_tm5tm2	87949	0.245	1.724	-0.512	-0.063	0.511

Panel B: Under-depreciation and Future Write-offs				
	Write-off (t+1)	**Write-off (t+2)**	**Write-off (t+3)**	**Future_writeoff**
intercept	-0.102***	-0.096***	-0.091***	-0.019***
	(-62.65)	(-59.16)	(-55.79)	(-32.44)
Underdep	*0.018*	*0.056****	*0.114****	*0.046****
	(1.24)	*(3.87)*	*(7.35)*	*(7.03)*
Write-off	0.199***	0.135***	0.069***	-0.686***
	(13.24)	(8.67)	(4.30)	(-24.73)
Logsale	0.002***	0.002***	0.002***	-0.000***
	(11.92)	(10.99)	(10.38)	(-3.63)
BTM_adj	0.012***	0.008***	0.006***	0.005***
	(15.64)	(10.35)	(7.68)	(14.95)
Ch_BTM	0.022***	0.014***	0.004	0.008***
	(6.37)	(3.92)	(1.12)	(5.13)
Ch_ROA	-0.093***	-0.018	-0.008	-0.008
	(-4.67)	(-0.87)	(-0.38)	(-0.94)
Ch_BTM_median	-0.046***	-0.072***	-0.090***	-0.043***
	(-7.65)	(-11.60)	(-13.92)	(-17.05)
Ch_ROA_median	-0.352***	-0.108**	-0.021	-0.071***
	(-7.19)	(-1.98)	(-0.38)	(-3.03)
Ch_sgrth_median	0.200***	0.194***	-0.010	0.066***
	(10.65)	(10.04)	(-0.51)	(8.04)
Hist_firm	0.019***	0.017***	0.014***	0.008***
	(41.16)	(34.52)	(29.45)	(33.97)
Gdw_intst	0.098***	0.092***	0.082***	0.055***
	(24.83)	(23.32)	(20.81)	(30.29)
Bhar_tm2tm1	-0.003***	-0.000	-0.002***	-0.001**
	(-3.26)	(-0.33)	(-2.70)	(-2.31)
Bhar_tm5tm2	0.001***	0.001**	0.001***	0.000***
	(5.11)	(2.29)	(3.54)	(3.94)
N	83785	79434	75065	75065

Table 4: Under-depreciation and Future Earnings

This table presents the results of OLS regression of *Underdep* (Under depreciation scaled by average total assets) on Future earnings. Panel A reports the descriptive statistics of the variables used in this regression. These variables are defined in the appendix. Panel B reports the results of OLS regression. Year and Industry fixed effects are included and t-statistics using robust standard errors that are clustered at year and industry level are presented in parentheses below coefficient estimates. All continuous variables are winsorized annually at their 1st and 99th percentiles. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

Panel A: Descriptive Statistics

	N	Mean	Std dev	First quartile	Median	Third quartile
Underdep	109229	0.013	0.033	-0.004	0.01	0.026
Earnings (t+1)	103185	0.023	0.118	0.005	0.043	0.079
Earnings (t+2)	97136	0.021	0.121	0.003	0.042	0.079
Earnings(t+3)	91239	0.02	0.122	0.003	0.041	0.078
Future_earnings	91051	-0.012	0.091	-0.038	-0.005	0.018
Earnings	109229	0.031	0.106	0.008	0.044	0.082
Logmve	109229	5.229	2.18	3.565	5.114	6.768
R&D	109229	0.028	0.057	0	0	0.028
SG&A	109229	0.255	0.229	0.085	0.204	0.361
Leverage	109229	0.693	1.137	0.08	0.308	0.809
Earnings_growth	109229	-0.261	3.303	-0.629	-0.084	0.208
Loss_dummy	109229	0.212	0.409	0	0	0

Panel B: Under-depreciation and Future Earnings

	Earnings (t+1)	Earnings (t+2)	Earnings (t+3)	Future_earnings
Intercept	-0.018***	-0.024***	-0.028***	-0.023***
	(-3.81)	(-3.56)	(-3.79)	(-3.70)
Underdep	*-0.024*	*-0.142****	*-0.168****	*-0.111****
	(-1.12)	*(-5.42)*	*(-5.59)*	*(-4.87)*
Earnings	0.588***	0.446***	0.385***	-0.498***
	(24.30)	(16.33)	(14.93)	(-20.18)
Logmve	0.006***	0.007***	0.008***	0.007***
	(7.74)	(7.25)	(7.16)	(7.41)
R&D	-0.234***	-0.291***	-0.315***	-0.259***
	(-4.47)	(-4.56)	(-4.93)	(-4.58)
SG&A	0.010	0.015	0.016	0.016
	(1.22)	(1.38)	(1.34)	(1.56)
Leverage	-0.005***	-0.004***	-0.002**	-0.003***
	(-5.81)	(-4.80)	(-2.67)	(-4.04)
Earnings_growth	-0.000*	-0.000*	-0.000*	-0.000**
	(-1.93)	(-1.73)	(-1.91)	(-2.45)
Loss_dummy	-0.010***	-0.009**	-0.004	-0.005
	(-2.87)	(-2.55)	(-1.15)	(-1.57)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj.R-squared	0.425	0.286	0.229	0.267
N	103185	97136	91239	91051

Table 5: Under-depreciation and Future Returns

This table presents the results of Fama-Macbeth cross sectional regressions of *Underdep_indadj* (Under depreciation scaled by average total assets and adjusted for the industry median) on future excess returns. Excess returns are computed by subtracting risk free return (treasury bill rate) from the raw returns. In Panel A, the dependent variable is buy & hold annual excess returns from May 1974 to April 2017. The predictor variables are updated once per year in the month of April and the accounting data pertains to the fiscal year ending in calendar year t-1 (annual rebalancing). In Panel B, the dependent variable is the monthly excess return with annual rebalancing and in panel C, the dependent variable is the monthly excess return with monthly rebalancing, where predictor variables are updated every month with the accounting data from the nearest available fiscal year with a gap of four months from fiscal year end. Logsize is the natural logarithm of market value of equity measured using CRSP data before the return measurement period. Logbeme is the natural logarithm of book-to-market ratio measured at the end of fiscal year end. Mom is momentum computed for last twelve months before the return start date skipping the final month. Opbe is the operating profitability. Invacc is the long-term investment accrual (defined in the appendix). All predictor variables are winsorized annually at their 1st and 99th percentiles. The t-statistics are adjusted for autocorrelation in the beta estimates using Newey-West consistent standard errors estimated with 3 lags. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

Panel A: Buy & Hold Annual Excess Returns with Annual Rebalancing

	Buy & Hold Annual Excess Returns			
Underdep_indadj	-0.439***	-0.364***	-0.372***	-0.368***
	(-3.85)	(-3.45)	(-3.50)	(-3.71)
Logsize		-0.006	-0.006	-0.009*
		(-1.06)	(-1.28)	(-1.69)
Logbeme		0.030**	0.030***	0.036***
		(2.61)	(2.86)	(2.93)
Mom			0.019	
			(0.77)	
Opbe				0.127***
				(4.17)
Invacc				-0.139***
				(-4.83)
Intercept	0.115***	0.142***	0.136***	0.144***
	(5.32)	(3.23)	(3.15)	(3.38)
Adj.R-squared	0.002	0.029	0.034	0.039
Average Observations	2364	2364	2364	2364

Panel B: Monthly Excess Returns with Annual Rebalancing

	Monthly Excess Returns			
Underdep_indadj	-0.035***	-0.030***	-0.030***	-0.032***
	(-4.66)	(-4.22)	(-4.27)	(-4.40)
Logsize		-0.001	-0.001	-0.001*
		(-1.25)	(-1.40)	(-1.88)
Logbeme		0.002***	0.002***	0.003***
		(2.71)	(3.05)	(2.98)
Mom			0.001	
			(1.02)	
Opbe				0.009***
				(4.59)
Invacc				-0.013***
				(-5.87)
Intercept	0.010***	0.013***	0.012***	0.013***
	(3.66)	(2.89)	(2.91)	(3.05)
Adj.R-squared	0.001	0.017	0.022	0.023
Average Observations	2253	2253	2253	2253

Panel C: Monthly Excess Returns with Monthly Rebalancing

	Monthly Excess Returns			
Underdep_indadj	-0.033***	-0.028***	-0.031***	-0.031***
	(-4.36)	(-3.70)	(-4.25)	(-4.18)
Logsize		-0.001	-0.001**	-0.001**
		(-1.60)	(-2.02)	(-2.35)
Logbeme		0.002**	0.002***	0.002***
		(2.56)	(2.78)	(2.67)
Mom			0.005**	
			(2.47)	
Opbe				0.010***
				(4.98)
Invacc				-0.015***
				(-6.72)
Intercept	0.010***	0.014***	0.013***	0.015***
	(3.67)	(3.07)	(3.15)	(3.25)
Adj.R-squared	0.001	0.018	0.026	0.024
Average Observations	2301	2301	2301	2301

Table 6: Abnormal Returns on Zero-Investment Portfolios

This table reports the annualized returns on Zero-Investment portfolios obtained by going long on the highest decile portfolio and short on the lowest decile portfolio. Each firm is assigned to one of the ten ranked portfolios based on the levels of under-depreciation in the last fiscal year. The assignment is performed four months after the end of the fiscal year, assuming that by then the financial statements are disclosed. Panel A reports the results for portfolios formed by annual rebalancing where the assignment remains constant for the next 12 months—that is, from the 5th through the 16th month after the fiscal year ends. Panel B reports the results for portfolios formed by monthly rebalancing where the assignment is updated every month based on the level of under-depreciation computed using the accounting data from the nearest available fiscal year with a gap of four months from fiscal year end. The zero-investment portfolio raw return (alpha) for a month is calculated by subtracting the raw return (alpha) for the lowest-ranked portfolio from that of the highest-ranked portfolio. The returns are annualized by multiplying by 12. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

Panel A: Portfolios Formed by Annual Rebalancing

	Equal-Weighted Returns			Value-Weighted Returns		
N= 43 years	Raw Return	Carhart 4 factor alpha	Fama-French 5 factor alpha	Raw Return	Carhart 4 factor alpha	Fama-French 5 factor alpha
Annualized Return	-4.38%	-3.97%	-3.72%	-3.60%	-3.35%	-2.89%
t-Statistic	*-4.90*	*-4.48*	*-4.07*	*-4.36*	*-4.11*	*-3.45*

Panel B: Portfolios Formed by Monthly Rebalancing

	Equal-Weighted Returns			Value-Weighted Returns		
N= 43 years	Raw Return	Carhart 4 factor alpha	Fama-French 5 factor alpha	Raw Return	Carhart 4 factor alpha	Fama-French 5 factor alpha
Annualized Return	-4.36%	-4.21%	-4.11%	-3.22%	-3.25%	-2.77%
t-Statistic	*-4.65*	*-4.48*	*-4.26*	*-3.53*	*-3.59*	*-3.03*

Table 7: Under-investment and Future Investments

This table presents the results of OLS regression of *Underinvest* (difference between maintenance capex and current investments in long-term assets scaled by average total assets) on Future investments. Panel A reports the descriptive statistics of the variables used in this regression. These variables are defined in appendix A. Panel B reports the results of OLS regression where the dependent variables are future investments. Panel C reports the results of OLS regression where the dependent variables are future abnormal investments. Year and Industry fixed effects are included and t-statistics using robust standard errors that are clustered at year and industry level are presented in parentheses below coefficient estimates. All continuous variables are winsorized annually at their 1st and 99th percentiles. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

Panel A: Descriptive Statistics

	N	**Mean**	**Std dev**	**First quartile**	**Median**	**Third quartile**
Underinvest	109249	-0.048	0.136	-0.082	-0.022	0.017
Invst (t+1)	103197	0.101	0.133	0.035	0.074	0.136
Invst (t+2)	97145	0.096	0.134	0.034	0.072	0.132
Invst (t+3)	91249	0.095	0.136	0.033	0.072	0.131
Future_invst	91062	-0.010	0.145	-0.049	0.003	0.050
abinvst (t+1)	103197	0.074	2.758	-0.651	-0.184	0.440
abinvst (t+2)	97145	0.065	2.959	-0.687	-0.215	0.464
abinvst (t+3)	91249	0.100	3.206	-0.703	-0.227	0.481
Invst	109249	0.108	0.140	0.036	0.076	0.141
Leverage	109249	0.693	1.137	0.080	0.308	0.809
Logmve	109249	5.229	2.180	3.565	5.114	6.768
Logage	109249	2.814	0.632	2.303	2.833	3.296
Cash_stock	109249	0.118	0.148	0.020	0.059	0.158
BTM	109249	0.880	0.725	0.396	0.689	1.132

Panel B: Under-investment and Future Investments

	Invst (t+1)	Invst (t+2)	Invst (t+3)	Future_invst
Intercept	0.110***	0.109***	0.105***	0.102***
	(10.44)	(10.68)	(11.59)	(10.76)
Underinvest	*0.340****	*0.328****	*0.303****	*0.376****
	(12.03)	*(8.58)*	*(6.70)*	*(9.93)*
Invst	0.510***	0.430***	0.390***	-0.500***
	(15.23)	(12.08)	(9.19)	(-13.54)
Leverage	-0.011***	-0.009***	-0.006***	-0.010***
	(-6.49)	(-5.90)	(-4.63)	(-6.74)
Logmve	0.003***	0.002**	0.001	0.002***
	(3.49)	(2.22)	(1.30)	(2.86)
Logage	-0.016***	-0.012***	-0.010***	-0.013***

	(-10.40)	(-8.88)	(-8.00)	(-10.81)
Cash_stock	0.031***	0.015**	0.009*	0.023***
	(5.17)	(2.59)	(1.86)	(4.62)
BTM	-0.016***	-0.016***	-0.014***	-0.014***
	(-4.86)	(-5.37)	(-5.90)	(-4.88)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj.R-squared	0.137	0.091	0.070	0.625
N	103197	97145	91249	91062

Panel C: Under-investment and Future Abnormal Investments

	Abinvst (t+1)	Abinvst (t+2)	Abinvst (t+3)
Intercept	0.215***	0.239***	0.161**
	(4.19)	(3.18)	(2.27)
Underinvest	*0.799****	*1.097****	*1.323****
	(8.85)	*(11.89)*	*(8.58)*
Leverage	-0.149***	-0.138***	-0.091***
	(-8.08)	(-8.60)	(-4.55)
Logmve	0.005	-0.008	-0.029***
	(0.63)	(-0.90)	(-3.91)
Logage	-0.008	0.013	0.081***
	(-0.41)	(0.53)	(4.20)
Cash_stock	0.646***	0.347***	0.544***
	(7.70)	(4.14)	(5.38)
BTM	-0.088***	-0.070*	-0.082*
	(-3.38)	(-2.02)	(-1.80)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Adj.R-squared	0.011	0.010	0.011
N	103197	97145	91249

Table 8: Re-examining the Relationship Between Investment and Future Stock Returns

This table presents the results of Fama-Macbeth regressions of *Mcap* (Maintenance Capex) interacted with *Invacc* (Total investment in long-term assets, defined in the appendix) on future excess returns. Excess returns are computed by subtracting risk free return (treasury bill rate is used) from the raw returns. In Panel A, the dependent variable is the monthly excess return from May 1974 to April 2017 with annual rebalancing, where the predictor variables are updated once per year in the month of April and the accounting data pertains to the fiscal year ending in calendar year t-1. In panel B, the dependent variable is the monthly excess return for the same period with monthly rebalancing, where predictor variables are updated every month with the accounting data from the nearest available fiscal year with a gap of four months from fiscal year end. Logsize is the natural logarithm of market value of equity measured using CRSP data before the return measurement period. Logbeme is the natural logarithm of book-to-market ratio measured at the end of fiscal year end. Mom is momentum computed for last twelve months before the return start date skipping the final month. Opbe is the operating profitability. All predictor variables are winsorized annually at their 1st and 99th percentiles. The t-statistics are adjusted for autocorrelation in the beta estimates using Newey-West consistent standard errors estimated with 3 lags. *, **, and *** indicate two-tailed statistical significance at 10, 5, and 1 percent levels, respectively.

Panel A: Monthly Excess Returns with Annual Rebalancing

	Monthly Excess Returns		
Invacc	-0.012***	-0.010***	-0.003
	(-5.80)	(-3.47)	(-0.71)
D&A		0.047***	
		(3.31)	
Invacc * D&A		-0.083*	
		(-1.75)	
Mcap			0.027*
			(1.93)
Invacc * Mcap			-0.158**
			(-2.51)
Logsize	-0.001*	-0.001*	-0.001*
	(-1.89)	(-1.85)	(-1.82)
Logbeme	0.003***	0.003***	0.003***
	(3.41)	(3.33)	(3.78)
Mom	0.001	0.001	0.001
	(0.50)	(0.45)	(0.47)
Opbe	0.009***	0.008***	0.009***
	(4.66)	(4.12)	(4.48)
Intercept	0.012***	0.010***	0.011***
	(3.01)	(2.65)	(2.76)
Adj.R-squared	0.027	0.029	0.029
Average observations	2253	2253	2253

Panel B: Monthly Excess Returns with Monthly Rebalancing

	Monthly Excess Returns		
Invacc	-0.014***	-0.010***	-0.004
	(-6.45)	(-3.36)	(-1.02)
D&A		0.051***	
		(3.41)	
Invacc * D&A		-0.111**	
		(-2.22)	
Mcap			0.023
			(1.56)
Invacc * Mcap			-0.149**
			(-2.32)
Logsize	-0.001***	-0.001***	-0.001***
	(-2.66)	(-2.66)	(-2.66)
Logbeme	0.003***	0.002***	0.003***
	(3.06)	(3.01)	(3.33)
Mom	0.004**	0.004**	0.004**
	(2.08)	(2.03)	(2.03)
Opbe	0.009***	0.008***	0.009***
	(4.92)	(4.41)	(4.75)
Intercept	0.014***	0.012***	0.013***
	(3.31)	(2.93)	(3.12)
Adj.R-squared	0.030	0.035	0.032
Average Observations	2301	2301	2301