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ABSTRACT

We argue that the CAPM may be a reasonable model for estimating the cost of capital for projects in spite of increasing criticisms in the empirical asset pricing literature. Following Hoberg and Welch (2007), we first show that there is more support for the CAPM than has been previously thought. We then present evidence that is consistent with the view that the option to modify existing projects and undertake new projects available to firms may be an important reason for the poor performance of the CAPM in explaining the cross section of returns on size and book-to-market sorted stock portfolios. That lends support to the McDonald and Siegel (1985) and Berk, Green and Naik (1999) observation that stock returns need not satisfy the CAPM even when the expected returns on all individual projects do. From the perspective of a person who believes that the CAPM provides a reasonable estimate of the required return on elementary individual projects, the empirical evidence in the literature is not sufficient to abandon the use of the CAPM in favor of other models.

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1. Introduction

The Sharpe (1964) and Lintner (1965) Capital Asset Pricing Model (CAPM) is the workhorse of finance for estimating the cost of capital for *project* selection. In spite of increasing criticism in the empirical academic literature, the CAPM continues to be the preferred model for classroom use in managerial finance courses in business schools, and managers continue to use it. Welch (2008) finds that about 75% of finance professors recommend using the CAPM for estimating the cost of capital for capital budgeting purposes. A survey of CFOs by Graham and Harvey (2001) indicates that 73.5% of the responding financial executives use the CAPM.

The primary empirical challenge to the CAPM comes from several well-documented anomalies: several managed portfolios constructed using various firm characteristics earn very different returns on average than those predicted by the CAPM. The question we want to examine is whether these anomalies should stop us from using the CAPM for estimating the cost of capital for undertaking a project. Notable among the anomalies that challenge the validity of the CAPM are the findings that the average returns on stocks is related to firm size (Banz (1981)), earnings to price ratio (Basu (1983)), book-to-market value of equity (BM) (Rosenberg, Reid, and Lanstein (1985)), cash flow to price ratio, sales growth (Lakonishok, Shleifer and Vishny (1994)), past returns (DeBondt and Thaler (1985) and Jegadeesh and Titman (1993)), and past earnings announcement surprise (Ball and Brown (1968)). Numerous subsequent studies confirm the presence of similar patterns in different datasets, including those of international markets. Fama and French (1993) conjecture that two additional risk factors, in addition to the stock market factor used in empirical implementations of the CAPM, are necessary to fully characterize economy wide pervasive risk in stocks. The Fama and French (1993) three-factor model has received wide attention and has become the standard model for computing risk adjusted returns in the empirical finance literature.

Almost all the existing anomalies apply to the *stock* return of a firm. Should such anomalies prevent one from using CAPM in calculating the cost of capital for a *project*? In this paper, we review the related literature and provide new empirical evidence to argue that there is little evidence against the use of the CAPM for estimating the cost of capital for *projects*.

Most firms have the option to turn down, undertake or defer a new project, in addition to the option to modify or terminate an existing project. Therefore, a firm can be viewed as a collection of existing and future projects and complex options on those projects. McDonald and Siegel (1985) observe that a firm should optimally exercise these real options to maximize its total value. The resulting firm value will consist of both the NPVs of the projects and the value of associated real options which is determined by how those options are expected to be exercised by the firm. Berk, Green and Naik (1999) build on that insight and present a model where the expected returns on all projects satisfy the CAPM but the expected returns on the firm's stocks do not. That is because, as Dybvig and Ingersoll (1982) and Hansen and Richard (1987) show, while the CAPM will assign the right expected returns to the primitive assets (projects), it will in general assign the wrong expected returns to options on those primitive assets. Gomes, Kogan and Zhang (2003), Carlson, Fisher and Giammarino (2004), Cooper (2006), and Zhang (2005) provide several additional insights by building on the Berk, Green and Naik (1999) framework. Anderson and Garcia-Feijoo (2006) and Xing (2007) find that the BM effect disappears when one controls for proxies for firms' investment activities. Bernardo, Chowdhry and Goyal (2007) highlight the importance of separating out the growth option from equity beta. Jagannathan and Wang (1996) argue that because of the nature of the real options vested with firms, the systematic risk of firms will vary depending on economic conditions, and the stock returns of such firms will exhibit option like behavior. An econometrician using standard time series methods may conclude that the CAPM does not hold for such firms, even when the returns on such firms satisfy the CAPM in a conditional sense.

We illustrate the impact of real options through a stylized numerical example in the next section. When the sensitivity of firms' stock returns to economy wide risk factors changes in nonlinear ways due to the presence of such real options, it may be necessary to use excess returns on certain cleverly managed portfolios (like the Fama and French

(1993) SMB and HML factors) as additional risk factors to explain the cross section of stock returns, even when returns on individual primitive projects satisfy the CAPM. If that were the case, the continued use of the CAPM for estimating the cost of capital for projects would be justified, in spite of the inability of the CAPM to explain the cross-section of average returns on the 25 size and book-to-market sorted benchmark stock portfolios.

In the illustrative example in the next section, a value premium arises since the "value" option is modeled to have higher beta after a market downturn when the expected risk premium is high, consistent with the conditional CAPM model of Jagannathan and Wang (1996) and the empirical evidence provided by Petkova and Zhang (2005). Lewellen and Nagel (2006), however, argue that the variation in betas and the equity premium would have to be implausibly large for the conditional CAPM to explain the magnitude of the value premium. Lewellen and Nagel (2006) make use of high-frequency returns in their empirical analysis. Chan, Hameed and Lau (2003) demonstrate that price and return may be in part driven by factors unrelated to fundamental cash flow risk. Such factors, together with liquidity events, may contaminate the estimation of beta at higher frequencies (see Pastor and Stambaugh (2003)). Bali, Cakici, and Tang (2009) and Bauer, Cosemans, Frehen and Schotman (2009) improve the cross-sectional performance of the conditional CAPM by using more efficient estimation techniques. In addition, recent studies by Kumar, Srescu, Boehme and Danielsen (2008) and Adrian and Franzoni (2008) demonstrate that once the estimation risk or parameter uncertainty associated with beta and risk premium are accounted for, the conditional CAPM will have significantly more explanatory power in the cross-section and may explain the value premium after all.

We provide several empirical observations supporting the use of the CAPM for calculating the cost of capital of a project. We first document stronger empirical support for the CAPM when we follow the suggestion of Hoberg and Welch (2007) and use aged betas. In particular, we find that the CAPM performs well in pricing the average returns on ten CAPM-beta-sorted portfolios during the period 1932-2007 once we skip two years after portfolio formation. The CAPM cannot be rejected using the Gibbons, Ross, and

Shanken (1989) GRS test. The CAPM beta explains 81% of the cross-sectional variation in average returns across the ten portfolios. The additional explanatory power of the Fama-French three-factor model that uses two additional pervasive risk factors is small.

We then focus on the book-to-market (BM) anomaly. Schwert (2003) argues that most of the anomalies are more apparent than real and often disappear after they have been noticed and publicized.[2] As we are examining the use of the CAPM for project cost of capital calculation, we limit attention to anomalies that are (1) pervasive and not driven by stocks of very small firms; (2) persistent over longer horizons; and (3) robust in the sense that the anomaly does not disappear soon after its discovery. The BM effect is probably the most important anomaly satisfying these criteria (see Fama and French (2006)).

Lakonishok, Shleifer and Vishny (1994) argue that high book-to-market stocks earn a higher return because they are underpriced to start with, and not because they have higher exposure to systematic risk. Consistent with that point of view, Daniel and Titman (1997) find that firms' characteristics help explain the cross-section of returns. Piotroski (2000) provides evidence consistent with the presence of mispricing by showing that among high book-to-market stocks firms with better fundamentals outperform the rest. Mohanram (2005) reaches a similar conclusion for low book-to-market stocks. Finally, Ferson, Sarkissian, and Simin (1998) argue that returns on portfolios constructed using stock attribute may appear to be useful risk factors, even when the attributes are completely unrelated to risk. Clearly, if the BM effect is indeed due to mispricing and unrelated to risk, it should not invalidate the use of the CAPM in cost of capital calculations as argued by Stein (1996).

We provide additional evidence that the existence of the BM effect, even if due to systematic risk, should not prevent the use of CAPM for calculating project cost of capital. We first show that the BM effect is mostly a *within-industry* effect (rather than

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[2] The interested reader is referred to Schwert (2003) for an excellent and comprehensive survey of financial markets anomalies literature.

across-industry). We then examine the extent to which BM may proxy for the cross section of stock returns because of the existence of real options. We find that BM is positively related to financial leverage, a measure of the real options associated with financial distress, and negatively related to measures of growth options available to a firm. When we examine the BM effect using within-industry debt-to-equity/BM double-sorted portfolios, we find that the BM effect is concentrated within high debt-to-equity portfolios. Further, once we control for variations in leverage and capital expenditure intensity across firms in the same industry, BM effects are only significant for firms that are small, with high debt-to-equity ratios and lower interest coverage, i.e., firms that are likely to have higher value for their real options. All this is consistent with a major part of the within industry book-to-market effect being due to a firm's option to terminate or modify existing projects and to undertake or defer new projects.

Most of the asset pricing tests use average historical returns to measure the expected returns. Recent studies have viewed realized return as a poor and biased proxy for investor expectation, and have proposed that a direct measure of *expected* return should be used for asset price tests.[3] There is a fairly large literature in accounting (See Easton (2008) and the reference therein) that computes the implied cost of capital (ICC) using equity analysts' earnings forecasts. As these forecasts are *ex-ante,* ICC may measure the expected returns better, provided the assumptions supporting the ICC estimates are valid. Claus and Thomas (2001) and Pastor, Sinha and Swaminathan (2007) argue that ICC may capture the dynamics of the equity risk premium as well. Since ICC, by definition, is the internal rate of return at which the stock price equals the present value of all expected future dividends, it would be a more appropriate measure of the expected return on long lived projects that firms may encounter in their capital budgeting decisions. For those reasons, we also investigate the BM effect using ICC as a measure of expected return and find the BM effect to be much weaker.

Finally, we provide direct empirical evidence supporting the view that the failure of CAPM in explaining the cross-section of stock returns is due to real options available to a

[3] See Elton (1999), Jagannathan, McGrattan, and Scherbina (2000), and Lewellen and Shanken (2002).

firm. When we sort stocks according to proxies of real options, we find that while CAPM does not explain the average stock returns among firms that have a significant amount of real options, it does a reasonable job in explaining the stocks returns among firms with few real options.

The determination of cost of capital has been an important and fruitful area of research in finance. Fama and French, in a series of papers, make a convincing case that CAPM fails to describe the cross-section of stock returns (Fama and French (1992, 1996, 1997, 1999, 2004 and 2006). Among many other related works, Ferson and Locke (1998) find that the great majority of the error in estimating the cost of equity capital using the CAPM is due to the risk premium estimate; Pastor and Stambaugh (1999) show that the cost of equity estimation can be improved in a Bayesian framework; Ang and Liu (2004) discuss a general approach for discounting cashflows with time-varying expected returns.

In this paper, our primary interest is in evaluating the empirical evidence against the use of CAPM based estimates of costs of capital for elementary projects for making capital budgeting decisions. In contrast, the focus of most of the studies in the asset pricing literature is in understanding the determinants of expected returns on stocks. In view of that, we refer readers interested in the broader asset pricing literature to the excellent surveys by Campbell (2003), Ferson (2003), Mehra and Prescott (2003), and Duffie (2003).

Following this introduction, we illustrate the impact of real options through a stylized numerical example in Section 2. Section 3 describes our data. Section 4 presents empirical evidence that performance of the CAPM in explaining returns improves when we follow the suggestions of Hoberg and Welch (2007). Section 5 takes a closer look at the BM effect. Section 6 examines the performance of CAPM among firms with different amount of real options, and Section 7 concludes.

2. A Real Option Example

In this section, we present a simple example to illustrate our main point— in an economy where CAPM correctly prices all primitive projects, stock returns can exhibit size and BM effects. Further, the example is consistent with the following additional empirical regularities:

- Value stocks have higher expected returns than the market and have positive CAPM alphas;
- Growth stocks have lower expected returns than the market and have negative CAPM alphas;
- Value stocks have lower CAPM betas than growth stocks;
- Equity risk premium is countercyclical;
- Value stocks are riskier than growth stocks when the expected risk premium is high;
- Size and book-to-market ratio can describe cross-sectional variation in expected returns on stocks.

2.1 The Economy

For illustrative purposes, we consider an economy with a risk premium of 5% per year, an annual risk free rate of 5%, and a flat yield curve.

There are three possible states at the end of the year: Up (probability: 25%), Mid (probability: 50%) and Down (probability: 25%). The returns on the market portfolios in these three states are: 40.4%, 8.0% and -16.3%, respectively, translating to an expected return of 10.0%.

All existing projects in this economy are identical, with an initial cost of \$1. Once undertaken, each project pays out an expected perpetual cash flow of \$0.2. All projects have a CAPM beta of 1 (as the market consists of those identical projects), with an appropriate discount rate of 10% (5% + 1× 5% = 10% as predicted by CAPM). The market value of each project is therefore 0.2/10% = \$2.

Consider a firm which has undertaken I projects. The book value of the firm is \$I and its market value is \$2I. Note that the firm, which is a portfolio of I projects each with a CAPM beta of 1, also has a CAPM beta of 1. Therefore, the expected return for the firm would be 10% per year, as described by the CAPM. Note also that the book-to-market ratio (\$I/\$2I = 0.5) does not have additional predictive power of the firm's expected return.

We now introduce two types of options in the economy: a value option (VO) and a growth option (GO). Each firm in the economy is randomly endowed with one of the two options. With either option, the firm has the capacity for investing in at most one more new project, with an initial cost of \$1, either now or one year later. If the firm chooses to invest now, it will get a project identical to its existing project (with an expected perpetual annual cash flow of \$0.2). However, if the firm chooses to wait a year, the expected perpetual annual cash flow of the project will change. In the case of the value option, the expected annual cash flow will be \$0.2423 in the Up state, \$0.2423 in the Mid state and \$0.1685 in the Down state. In the case of the growth option, the expected annual cash flow will be \$0.3711 in the Up state, \$0.2643 in the Mid state and \$0.2643 in the Down state. With both options, the investment opportunity disappears after one year. As such, the options exist only for the first year after which the economy will consist of only primitive projects. This is clearly a simplified assumption used for illustrative purpose only. Berk, Green and Naik (1999) present a much more realistic model where new projects arrive and old projects die on a dynamic basis. The firm's option to invest in this case resembles the "option-to-wait" analyzed in McDonald and Siegel (1985) and discussed in Jagannathan and Meier (2002).

We summarize the information about these two options in the following table:

State	Probability	Expected annual value option (VO) cash flow (1)	NPV VO cash flow =(1)/0.1-1	Expected annual growth option (GO) cash flow (2)	NPV GO cash flow =(2)/0.1-1
Up	0.25	\$0.2423	\$1.423	\$0.3711	\$2.711
Mid	0.50	\$0.2423	\$1.423	\$0.2643	\$1.643
Down	0.25	\$0.1685	\$0.685	\$0.2643	\$1.643

Since all project cashflows are associated with CAPM betas of 1 and costs of \$1, their NPVs can be computed by discounting the expected annual cashflows at 10% and subtracting \$1. Since the NPVs are all positive, the projects will always be undertaken at the end of the year (if they have not been undertaken at the beginning of the year).

2.2 Prices and Expected Returns

For pricing purpose, we assume a state price vector (or the Stochastic Discount Factor, SDF for short) M = [0.7313, 0.8164, 1.4454]' across Up, Mid and Down states, respectively. It can be verified that E[M(1+R)] = 1 for the risk free rate and the market return, meaning the SDF can price the risk free asset and the market portfolio.

With the state price vector, we can price the two options using E[M*payoff]. The results are summarized in the following table:

State	Prob	State Price (M)	Riskfree Rate	Market Return	VO payoff	VO Return	GO payoff	Go Return
Up	0.25	0.7313	5.0%	40.4%	\$1.423	30.7%	\$2.711	54.0%
Mid	0.50	0.8164	5.0%	8.0%	\$1.423	30.7%	\$1.643	-6.6%
Down	0.25	1.4454	5.0%	-16.3%	\$0.685	-37.1%	\$1.643	-6.6%
price					\$1.088		\$1.760	
ER			5.0%	10.0%		13.8%		8.5%
CAPM beta			0.00	1.00		1.10		1.14
CAPM ER				10.0%		10.5%		10.7%

The value option has a value of \$1.088 today, higher than the payoff if the project were to be taken today (\$0.2/0.1-1 = \$1), which means the firm will choose to wait. The growth option has a value of \$1.760 today, also higher than the payoff if the projects were to be taken today, so the firm will choose to wait too.

Given the prices of these two options, we can compute their annual returns and expected returns. In addition, we can compute their covariances with the market and therefore their CAPM betas. We find that the value option (VO) has a higher expected return (13.8%) than the market while the growth option (GO) has a lower expected return (8.5%) than the market. Interestingly, the growth option has a higher CAPM beta.

Because of the higher CAPM beta, CAPM will predict a higher expected return on the growth option (10.7%) than the value option (10.5%). In other words, the CAPM, although perfectly explaining the expected returns on primitive projects in the economy, fails to explain the expected returns on these two options. As a result, the value option seems to "outperform" the market (it carries a positive CAPM alpha of 13.8%-10.5% = 3.3%) while the growth option seems to "underperform" the market (it carries a negative CAPM alpha of 8.5%-10.7% = - 2.2%).

2.3 Intuition

Why does the value option (VO) earn a higher expected return than the growth option (GO) in the simple economy? To see the underlying intuition clearly, we insert an "intermediate" time period into our example. Consequently, the one-period trinomial tree is expanded to be a two-period binomial tree. The payoffs to an investment in the market portfolio (assuming an initial investment of $1) are:

T = 0	T = Six month	T = One year
		Up (UU): $1.404
	U: $1.200	
$1.000		Mid (UD, DU): $1.080
	D: $0.900	
		Down (DD): $0.837

The risk free rate in each six-month period is $1.05^{0.5}$-1 = 2.47%.

Since there are two states (with equal probability) associated with each node on the binomial tree, the market is complete if both the stock and the bond can be traded on each node.[4] Both the value option and the growth option can be priced using the standard no-arbitrage replication argument (see Rubinstein (1976) among others):

Value Option (VO)			Growth Option (GO)		
T = 0	T = Six month	T = One year	T = 0	T = Six month	T = One year
		\$1.423			\$2.711
	\$1.389			\$2.085	
\$1.088		\$1.423	\$1.760		\$1.643
	\$0.921			\$1.604	
		\$0.685			\$1.643

Given the payoffs (and the implied returns) of both the market and the options, we can compute the following on both node U and D for the period from six month to one year:

State	ER (Market)	Beta (VO)	ER (VO)	Beta (GO)	ER (GO)
U	3.5%	0.00	2.5%	1.90	4.4%
D	6.5%	2.97	14.4%	0.00	2.5%

Note first that the expected return going forward on the market is higher following a negative market return in state (D), consistent with the empirical fact that risk premium is counter-cyclical. In addition, CAPM works for both options conditionally (on each node). This is not surprising since the option can be replicated by both the market and the bond and CAPM prices the expected returns on both assets (see Dybvig and Ross, 1985)

The value option is more risky unconditionally because it has higher beta in state D, precisely when the market risk premium is high. This is highlighted by Jagannathan and Korajczyk (1986) and is the key insight of the conditional CAPM model by Jagannathan and Wang (1996).

Are value stocks indeed more risky when the risk premium going forward is high? Several empirical evidences are provided in the literature suggesting the answer to be yes.

[4] It can be easily verified that M = [0.7313, 0.8164, 1.4454]' is the unique arbitrage-free SDF in this economy.

For example, Petkova and Zhang (2005) find that value betas tend to covary positively, and growth betas tend to covary negatively with the expected market risk premium.[5] Why are value stocks more risky when expected risk premium is high? Zhang (2005) provides one explanation. It is more costly for value firms to downsize their capital stocks since they are typically burdened with more unproductive capital. As a result, the value stocks' returns covary more with economic downturns when the expected risk premium is high.

2.4 Stock Characteristics

Despite the failure of CAPM in pricing options, book-to-market ratio and size of the firm will serve as two sufficient statistics in describing the expected returns of all firms in the economy. To see that, note that all firms in the economy have two components: (1) the asset-in-place component that includes I_i existing projects, and (2) an option component (O_i = VO or GO). The market value or size of each firm is: $V_i = 2I_i + O_i$. The expected return of the firm is a weighted-average of expected returns on these two components: $ER_i = 2I_i/V_i*10\% + O_i/V_i*ER_O$.

In the case that the firm has a value option,

$ER_i = 2I_i/V_i*10\% + 1.088/V_i*13.8\% = 20\%*BM_i + 15\%/Size_i$.

In the case that the firm has a growth option,

$ER_i = 2I_i/V_i*10\% + 1.760/V_i*8.5\% = 20\%*BM_i + 15\%/Size_i$.

In both cases, the expected return can be expressed as 20%*BM+15%/Size. Therefore the expected return is increasing with BM and decreasing with Size. In addition, BM and Size explain the expected returns on all firms.

Firms with the value option resemble "value" stocks. These firms have more assets-in-place and since the "value" option is cheaper, value stocks are associated with higher BM. Since the value option has higher expected return and positive CAPM alpha, so will the

[5] Other recent studies on the conditional CAPM include Wang (2003), Ang and Chen (2006). Similar evidences are provided in the context of consumption-CAPM by Lettau and Ludvigson (2001), Santos and Veronesi (2006), and Lustig and Van Nieuwerburgh (2005).

value stocks. Firms with the growth option resemble “growth” stocks. In contrast to value stocks, growth stocks have lower BMs, lower expected returns and negative CAPM alphas.

Why do characteristics such as BM and size describe cross-sectional return variations? The key intuition follows from Berk (1995). Given expectation about future payoffs, market value must be correlated with systematic risk across stocks. In the simple economy, BM summarizes the firm’s risk relative to the scale of its asset base and size describes the relative importance of existing assets and the option.

A series of recent papers combine the above intuition with key insights from the real option literature pioneered by McDonald and Siegel (1985) to link firm-specific investment patterns, valuation, and expected returns in a more realistic setting. The seminal paper by Berk, Green, and Naik (1999) studies the implications of the exercise of real investment options (for the dynamics of returns and risk across firms that are related to BM and size.) Investment opportunities with low systematic risk are attractive to the firm. Making such investments increases firm value and reduces the average risk of the firm. Consequently, the expected return of the firm is dynamically linked to price-based characteristics such as BM and size. Gomes, Kogan, and Zhang (2003) extend the model to a general equilibrium setting. Since size and BM are correlated with true conditional betas in their model, they help to explain stock returns in the cross section especially when true betas are measured with error empirically.

Carlson, Fisher, and Giammarino (2004) model the optimal dynamic investment behavior of monopolistic firms facing stochastic product market conditions. Their approach is similar in spirit to Berk et al. (1999) except that they also introduce operating leverage, reversible real options, fixed adjustment costs, and finite growth opportunities. They show that the BM effect can arise even if there is no cross-sectional dispersion in project risk as BM summarizes market demand conditions relative to invested capital.

Zhang (2005) demonstrates in an industry equilibrium model that a firm's optimal investments, together with asymmetry in capital adjustment costs and the countercyclical price of risk, can generate the BM effect. This is because value firms have difficulty disinvesting, making them more risky in bad times when the risk premium is high. On the other hand, Cooper (2006) develops a dynamic model in which BM is informative of the deviation of a firm's actual capital stock from its target. As a firm becomes distressed, its book-value remains constant but market value falls, resulting in a higher BM. Going forward, its extra installed capacity allows it to expand production easily without new investment, making its payoff more sensitive to aggregate shocks and its equity more risky. Empirically, Anderson and Garcia-Feijoo (2006) and Xing (2007) both provide supporting evidence that the investment dynamics of a firm is driving the BM effect.

In summary, our example illustrates that when primitive projects are associated with real options, the size and BM effects can arise. However, the size and BM effects do not necessarily imply that it is incorrect to use CAPM in calculating the costs of capital for primitive projects.

3. Sample Construction

We start with firms covered by CRSP with common shares outstanding over the period of 1932-2007. We focus on large and mature firms. As many market constituents actively produce and gather information for large firms, information asymmetry would be minimal and market investors are more likely to share common beliefs on firm prospects. Similarly, large firms are less likely to experience an extended period of mispricing. At the time we form portfolios of stocks, we therefore exclude firms with market capitalization less than the NYSE 10th percentile breakpoint, firms with a price of less than $5, as well as firms that are listed for less than 3 years. To minimize the effects of temporary price movement, we further exclude firms in the deciles with the highest/lowest *prior* 12-month stock returns (momentum stocks) in each June of the sample period. All the applied filters make use of information that is available at the time of portfolio formation, thus should not introduce any look-ahead bias. After applying these filters, our sample still covers 75% of the entire universe of CRSP stocks in terms of market capitalizations. In computing portfolio returns, we use CRSP delisting returns whenever appropriate. For stocks that disappear from the dataset due to delisting, merger or acquisition, we assume that we invest the proceeds from such events in the remaining portfolio.

For each sample firm in June of a given sample year, the following variables are constructed: Beta estimate (Beta) is obtained as the slope of the CAPM regression, using the prior 60 months of return records from CRSP. Size is measured as the market capitalization (in million) for a sample firm on the last trading day of June each year. Turnover is the average monthly trading volume as a percentage of the outstanding shares, while Momentum is the 12-month cumulative stock return, computed in the 12-month period prior to the portfolio formation.

Our CSRP sample is further intersected with COMPUSTAT data where the book values in June of the portfolio formation year are available. We require a minimum of 3-month gap in matching the accounting data of calendar year t-1 and return data of calendar year t to ensure that the accounting information is known for the use of portfolio construction in June. In our study, we match accounting data of firms with fiscal year end before/in March of calendar year t with returns for July of year t to June of year t+1. The following variables are constructed using information available from annual COMPUSTAT files: BE is the book value (in millions) as the sum of stockholders equity, deferred tax and investment tax credit, and convertible debt, minus the liquidation value of preferred stocks[6] (Kayhan and Titman (2003)). The data is further supplemented with historical equity data (Davis, Fama, and French (2000)) available from Ken French's website. BM is the book-to-market ratio (BE/SIZE), while DE is the debt-to-equity ratio, calculated as the difference of total assets and book value of equity, scaled by Size. We measure a sample firm's investment growth by its annual capital expenditure, scaled by annual sales (Capex). The majority of our empirical analysis is conducted using our CRSP/COMPUSTAT sample as described above.

[6] If the value of stockholder's equity is missing, we replace the value of BE with (total assets – total liabilities – liquidation value of preferred stocks, deferred tax and investment tax credit, and convertible debt).

For the analysis conducted using implied cost of capital, we focus on a sample of stocks covered by the I/B/E/S in the period of 1981 to 2006. Our CRSP/COMPUSTAT sample is merged with I/B/E/S to obtain information on earnings forecasts provided by financial analysts. We extract the number of analysts providing one-year-ahead earnings forecasts for a given firm (Nayst), and average long-term growth rate forecasts for a given firm (Grow) records each June from the I/B/E/S summary file. We also make use of monthly records on median values of one-year and two- year-ahead earnings forecasts, as well as long-term growth forecasts for the use of computing estimates on implied costs of capital (ICC).

For the ease of comparison, we summarize the variable definition in Table 1.

4. Stronger empirical support for the CAPM

In this section, we provide new evidence in support of the standard CAPM as a reasonable model in describing the average returns on large and mature stocks, which presumably are less prone to “mispricing.”

We work with beta-sorted portfolios. Specifically, we sort stocks in our sample, which consists mostly of large and mature firms, into ten portfolios by Beta in each June of 1932-2007. Again, Beta is estimated as the slope of the CAPM regression, using monthly return records in the previous five years of trading. On average, each of our ten beta-sorted portfolios consists of approximately 108 firms.

The descriptive statistics of characteristics for the Beta-sorted portfolios are presented in Panel A of Table 2. The average beta varies from a high of 2.09 for portfolio 1 (high Beta), to 0.36 for portfolio 10 (low Beta). Among the high Beta firms, analysts are more likely to provide higher growth estimates. High Beta firms also tend to have lower book-to-market (BM) and leverage (DE) ratios, with the average DE increasing monotonically from portfolio 2 to portfolio 9. There is no noticeable trend in Size and the number of analysts providing earnings forecasts (Nayst) across the ten portfolios.

The value-weighted monthly returns of the 10 Beta-sorted portfolios are used in our asset pricing tests. The average portfolio returns are computed up to the third year subsequent to portfolio formation. Our first-year average return ($Vwret_1$) corresponds to an average of monthly returns in the period of July (t) to June (t+1); similarly, $Vwret_3$ corresponds to the average return of July (t+2) to June (t+3). For Beta-sorted portfolios, the first-year average return ($Vwret_1$) ranges from 1.25% for portfolio 6 to 0.99% for portfolio 10, while the third-year average return ($Vwret_3$) ranges from 1.17% for portfolio 1 to 0.90% for portfolio 10. While portfolio returns positively correlate with Beta in the first year subsequent to portfolio formation, the correlation becomes stronger in the third year.

We compare the standard CAPM and the Fama-French three-factor model in our time series regression analysis on the 10 Beta-sorted portfolios. For each model, we compute the average pricing error as well as the Gibbons-Ross-Shanken (GRS) statistics for testing whether all the intercepts for the 10 portfolios are jointly zero. We analyze the correlation between the first-year portfolio returns and risk factors (as presented in Panel B of Table 2). There exists significant pricing error of 17 basis points per month with the standard CAPM, and the GRS statistics reject that all 10 intercepts are jointly zero. Including two more factors (SMB and HML) does not reduce the pricing error.

Hoberg and Welch (2007) argue that investors may be slow in adjusting to the recent change in market risk, and recommend the use of aged beta (beta from 2 to 10 years ago).[7] Table 2 gives the relative performance of the CAPM and the Fama and French three factor model using aged betas. The descriptive statistics in Panel A of Table 2 is consistent with Hoberg and Welch (2007). There is stronger relation between Beta and $Vwret_3$. As can be seen from Panel C of Table 2, when we use aged betas (i.e., skip two

[7] We find (not reported, available on request) that stocks migrating across beta-deciles recently pose the most challenge to the CAPM. Their realized return during the two years following a large increase (decrease) in beta tends to be relatively low (high) on a risk adjusted basis. In contrast, the third-year returns are less affected by such “transitory” component in return and thus are more appropriate to use for asset pricing tests.

years before forming portfolios based on their historical betas), the average absolute alpha drops to 10bp/month for both models; there is no evidence against either model according to the GRS statistic.

Notice that while the stock market betas of the ten portfolios exhibit substantial variation -- from a low of 0.61 to a high of 1.41 – there is little variation in the Fama and French SMB and HML factor betas. This lack of variation will work against the Fama and French (1993) three factor model when we use the cross sectional regression method (but not when we use the GRS time series method), we still report the results obtained using the cross sectional regression method in Panel D of Table 2 for completeness. For the CAPM, the cross sectional adjusted R-Square increases from 39% to 81% with the use of aged betas. There is not much gain from moving to the Fama and French three factor model for these ten portfolios.

5. Book-to-market effect, growth option and firm leverage

In this section, we focus on the most prominent empirical challenge to the CAPM, the book-to-market (value) effect, in that those stocks with higher book-to-market ratios tend to earn higher returns. In order to examine the book-to-market (BM) effect and its relevance for the project cost of capital calculation, we first separate the *within-industry* BM effect from the *cross-industry* BM effect.

5.1 BM effect is stronger within industry

We investigate the book-to-market effects within industries using industry portfolios categorized by Fama-French 10 industry classification. We first create terciles sorted by BM within each industry portfolio. Asset pricing tests are conducted on the value-weighted monthly portfolio returns in the first year of these 30 portfolios. To save space, we only tabulate the absolute pricing errors and GRS statistics of the time series regressions on these 30 portfolios in Panel A of Table 3. In the time series analysis, the CAPM generates a monthly pricing error of 17 basis points, with the GRS statistics rejecting that all 30 intercepts are jointly zero. However, the Fama-French three-factor model produces a larger pricing error of 19 basis points per month and increases the GRS statistics. In cross-sectional tests, the CAPM explains 33% of the average returns on BM-industry portfolios. The Fama-French three-factor specification adds 3% to the adjusted R-square, but weakens the significance of the market factor (MKT) and increases the intercept term. The intercept in the three-factor model is now significantly different from zero. Despite the added dispersion in the Industry-BM portfolios (created by additional sorting by BM), the Fama-French three-factor model does not significantly outperform the CAPM.

The variation of the BM ratio across the 30 portfolios can be decomposed into *within-industry* and *cross-industry* components. We isolate the *cross-industry* variation in the BM ratio by selecting one portfolio from each industry terciles such that the resulting 10 portfolios achieve the highest dispersion in the BM ratio. The characteristics of these 10 sub-industry portfolios are presented in Panel B in Table 3. The variation in the BM ratio of these sub-industry portfolios (ranging from 0.34 to 2.85) is noticeably larger than that of the 10 industry portfolios. If the BM effect is driven by *cross-industry* variation in the BM, we would expect to see a stronger relation between BM and return across the 10 sub-industry portfolios. That is clearly not the case. Sub-industry portfolio 10 with the highest BM of 2.85 has an average monthly return of 1.27%, which is only slightly higher than the 1.20% return of sub-industry portfolio 8 which has an average BM of only 0.34. The pattern is consistent with the argument that the value effect is mainly driven by *within-industry* variation in book-to-market ratios rather than the *cross-industry* variation as also documented by Cohen and Polk (1998). However, in their study, there is little *cross-industry* variation in BM.

We conduct asset pricing tests on these sub-industry portfolios. Results of time series and cross-sectional analyses are presented in Panel C and D of Table 3. In the time series analysis, the CAPM generates a monthly pricing error of 22 basis points, with the GRS statistics rejecting that all 10 intercepts are jointly zero. Although the Fama-French three-factor model produces a slightly lower pricing error of 19 basis points per month, the GRS statistics still reject that all 10 intercepts are jointly zero. In cross-sectional tests, the CAPM explains 45% of the average returns on BM-industry portfolios. The MKT factor is highly significant in capturing the cross-sectional variation of stock returns. The intercept term is not statistically significantly different from zero. The Fama-French three-factor specification adds only 6.5% to the adjusted R-square despite the large variation of BM across the test portfolios. The loading on HML does seem to drive out the CAPM beta. However, the CAPM betas and the factor loadings on HML are highly correlated across the 10 portfolios. As a result, a problem of multicollinearity emerges. As a potential sign of such a problem, the intercept in the three-factor model is now significantly different from zero. In other words, the small improvement of the three-factor model over the standard CAPM in the cross-sectional analysis here has to be interpreted with caution.

To summarize, we find that the BM effect is driven by *within-industry* rather than a*cross-industry* variation in book-to-market ratios. In what follows we examine the determinants of the *within-industry* BM effect and its relevance for project cost of capital calculation.

5.2 Evaluating the within-industry BM effect

To capture within industry variation in BM, we construct BM-deciles within each industry. Stocks in those industry deciles are then merged to give 10 portfolios. Portfolio 1 (10) contains stocks that from the highest (lowest) BM deciles of their corresponding industry. Characteristics of these 10 portfolios are presented in Panel A of Table 4.

Among the within-industry BM portfolios, Size increases monotonically from $711 million for the portfolio with the highest BM to $3,699 million for the portfolio with the lowest BM, while DE declines monotonically from the highest- to the lowest- BM portfolio. The Capex ratio ranges from 0.08 to 0.23 with the highest ratios in the two lowest-BM portfolios. Analysts' long term growth forecast for earnings (Grow) increases monotonically from 12% for the highest to 18% for the lowest BM portfolio. Analysts tend to disagree more on a firm's near-term future earnings for firms in the high BM portfolios. The first-year average return ($Vwret_1$) ranges from 1.32% for firms in portfolio 1 (high BM) to 0.91% for firms in portfolio 9 (low BM), confirming the presence of a within-industry BM effect.

We find that BM is highly correlated with financial leverage (DE) and capital expenditure (Capex). This is consistent with the view that the BM effect is to a large extent due to the nature of the real options available to a firm, since it is reasonable to expect financial leverage to be related to a firm's real options in the event of financial distress, and Capex to proxy for a firm's growth option.

We first investigate the interaction between the book-to-market ratio and the financial leverage in affecting stock returns. We construct portfolios sorted with DE and BM within industry. Sample firms are first categorized into portfolios by the Fama-French 10 industry classification in June of each year. Within each industry portfolio, firms are double-sorted into terciles first by DE and then by BM. Characteristics of these double-sorted portfolios are presented in Panel B of Table 4. The first-year average return ($Vwret_1$) ranges from 1.41% for firms in the high-DE/ high-BE portfolio to 0.93% for firms in the low-DE/low BE portfolio. Consistent with the empirical results in Griffin and Lemmon (2002), we find that sorting on BM generates dispersion in stock returns only among stocks with higher financial leverage. While high-BM stocks earn 34 bps per month more than low-BM stocks among high-DE stocks, they do not earn much higher returns than the low-BM stocks among low and medium DE stocks.

We then investigate the interaction among BM and other stock characteristics using Fama-MacBeth cross-sectional analysis at the individual stock level. The left side variable is the average monthly return on a stock. The right side variables are the various characteristics like aged Beta, Size, DE, Capex, and BM (with log-transformation applied to Size, BM and DE) of that stock. We focus on within-industry variations by demeaning all the variables within industry. The regression coefficients are then averaged across time and the t-values are computed using the Newey-West formula with a lag of 6 months. The results are presented in Panel C of Table 4.

BM exhibits significant positive correlation with individual stock returns, capturing 1.65% of the cross-sectional return variation. When aged Beta, Size, DE and Capex are incorporated into the model, the adjusted R-square increases to 4.88%. Both DE and Capex are highly significant in capturing the cross-sectional return variation. To test whether the DE and Capex could fully capture the BM effect, we create a fitted BM variable. Such fitted BM variable is generated in a cross-section regression of the actual BM ratio as a linear function of aged Beta, size, DE and Capex. The fitted BM is significantly related to stock returns, and captures a slightly higher percentage of cross-sectional return variation than the actual BM does. However, when including all three variables in the regression, BM and Capex are both significant predictors of stock returns, while the significance of DE is diminished by BM.

We examine whether the BM effect is more pronounced among firms with certain characteristics. In the cross-sectional analysis, we include the BM ratio multiplied by indicator dummy variables for Large/Small stocks, High/Low DE stocks, and stocks with High/Low Icov; where Icov is the inverse interest coverage ratio given by interest expense divided by operating income before depreciation. Our results indicate that BM effects are significant among small stocks, stocks with higher financial leverage (DE), and firms with lower interest coverage (higher Icov).

The results in this subsection suggest that within-industry variation in BM is related to financial leverage and Capex – measures of real options available to a firm. Once these two *firm* characteristics are controlled for, the BM effect is significantly reduced, and the BM effect is important mostly for firms that are more likely to be affected by financial distress. All this indicates that the BM effect is likely driven by the firm specific characteristics and not the characteristics of the underlying *projects*.

5.3Measuring expected return using the Implied Cost of Capital

In this subsection, we examine the Implied Cost of Capital (ICC) estimate based on the firm's current market valuation and expected future cash flows (proxied by analyst earnings forecasts). There are two important advantages of using ICCs for project cost of capital calculation. First, asset pricing models produce hypotheses on the correlation between *expected* returns and risk measures. However, the majority of asset price tests are conducted using realized return as a proxy for *expected* return. Recent studies (Elton (1999), Jagannathan, McGrattan, and Scherbina (2000), Lewellen and Shanken (2002)) have viewed realized return as a poor and biased proxy for investor expectation, and have proposed that a direct measure of *expected* return should be used for asset price tests. ICC is an *ex ante* measure of stock return. Second, computed as the internal rate of return at which the stock price equates the present value of future dividends, ICC captures the nature of the long life span of a typical project. This is in contrast to the one-period returns we have examined so far. One-year returns might not be sufficient in evaluating the cost of capital on a long-term project.

We follow the procedure in Pastor, Sinha and Swaminathan (2007) in constructing the ICC estimates:

$$P_t = \sum_{k=1}^{T} \frac{FE_{t+k}(1-b_{t+k})}{(1+ICC_t)^k} + \frac{FE_{t+T+1}}{ICC_t(1+ICC_t)^T}$$

where P_t is the stock price,
FE_{t+k} is the earnings forecast,
and b_{t+k} is the forecast of the plowback rate for the period $t+k$ made at t.

A fifteen (T=15) year horizon is used in our analysis, as in Pastor, Sinha and Swaminathan (2007). The earnings forecasts of the first three years in our ICC estimation are based on analyst forecast data available from I/B/E/S. In each month from 1981 to 2006, median values of one-year- and two-year- ahead earnings forecasts are gathered from I/B/E/S summary files and utilized as FT_{t+1} and FT_{t+2} in the ICC estimation procedure. The third-year forecast is computed as the product of FT_{t+2} and Grow (I/B/E/S long-term growth forecast). The earnings forecasts for the remaining periods of (t=4-15) are specified as:

$$FE_{t+k} = FE_{t+k-1} * (1 + g_{t+k})$$
$$g_{t+k} = g_{t+k-1} * \exp(\log(g / g_{t+3}) / (T-1))$$

The earnings growth follows an exponential rate of decline from g_{t+3} to the steady state growth rate (g). In our estimation, we assume that g equals the GNP growth rate.

In the first three years, the plow back rate (b_{t+k}, k = 1, 2, 3) is computed as one minus the firm's most recent net payout ratio, calculated as the sum of dividends and common/preferred stocks repurchased minus common/preferred stocks newly issued, scaled by the net income in that year .The plow back rate forecasts for the remaining periods of (t=4-15) are specified as:

$$b_{t+k} = b_{t+k-1} - \frac{b_{t+2} - b}{T - 1}$$

The sustainable growth rate formula then implies that the steady state plow back rate equals the ratio of steady state growth (g) to ICC. With inputs of I/B/E/S earnings forecasts, prior year of payout ratio, and historical GNP growth, the ICC is computed as the rate at which the stock price equates the present value of future dividends for each individual firm.

We generate the ICC estimates for the 10 within industry BM-sorted portfolios. The implied cost of capital (ICC) estimates and the corresponding analyst forecasts used to impute the ICCs are presented in Table 5. Across the 10 within industry BM-sorted portfolios, earnings forecasts in the forthcoming two years tend to be higher and long-term grow rate forecast are likely to be lower for firms with lower BM. The average steady state plow back rate (imputed from the estimation of ICCs) also tends to be higher for portfolios with lower BM.

For each portfolio, the earnings and dividend payout data are aggregated across firm, and the ICC is computed as the rate at which the portfolio value equates the present value of future dividends. For these 10 portfolios, there is limited variation in the computed ICCs at the portfolio level. In particular, the ICC on the highest BM portfolio (11.44%) is only

1.55% higher than that on the lowest-BM portfolio (9.89%). This illustrates that once the life span of the project is taken into consideration, the BM effect is alleviated.[8]

6. CAPM beta and growth options

As illustrated in our option example, while the CAPM will assign the right expected returns to the primitive assets (projects), it will in general assign the wrong expected returns to options on those primitive assets. As the sensitivity of firms' stock returns to economy wide risk factors changes in nonlinear ways due to the presence of real options, the CAPM beta's ability to explain the cross section of stock returns can be weakened, even when returns on individual primitive projects may satisfy the CAPM.

One direct test of whether the CAPM explains returns on the primitive assets (projects) is to examine the correlation between the CAPM beta and stock returns among firms with few real options. Garcia-Feijoo (2006) and Xing (2007) both report empirically that return predictability is related to a firm's optimal capital investment, consistent with the Berk, Green and Naik (1999) conclusion that the relative importance of asset-in-place and growth option changes over time in response to the optimal investment decision. We therefore examine how the cross sectional relation between the CAPM beta and stock return vary across firms having different levels of capital expenditure using the Fama-MacBeth procedure.

Each year in our sample period, we regress the monthly individual stock returns of the firms in the top and bottom Capex deciles on various stock characteristics including aged Beta, Size, BM, DE, Momentum, and Turnover, with log-transformation applied to Size, BM and DE. The regression coefficients are then averaged across time and the t-values are computed using the Newey-West formula with a lag of 6 months. The results are presented in Table 6.

[8] We do not directly test the standard one-period CAPM using the ICCs. The test will be mis-specified since ICCs correspond to expected returns over an infinite horizon. Magill and Quinzii (2000) and Cochrane (2008) lay out the theoretical foundation for an infinite-horizon CAPM equilibrium.

Aged Beta exhibits positive correlation with individual stock returns among firms in the bottom Capex decile . The correlation is marginally significant (with a *t* value of 1.82) for the coefficient for aged Beta in the three bottom Capex deciles. The significance of aged Beta improves (with *t* value of 3.88) when other variables such as Size, BM, DE, Momentum, and Turnover are incorporated into the model. The adjusted R-square increases to 13.89% in the bottom Capex decile. As we expected to find, the correlation between aged beta and stock return is significantly positive for stocks in the bottom Capex decile, suggesting that the CAPM performs reasonably among firms with very few real options. In contrast, the correlation between aged beta and stock return is much weaker for stocks in the top Capex decile.

7. Conclusion

In this paper, we evaluate the empirical evidence against the standard CAPM from the perspective of a person who believes that it provides a reasonable estimate of a project's cost of capital. For that we differentiate the required expected return on potential elementary projects available to a firm from the required expected return on a firm's stocks.

We first show that there is more support for the CAPM than has been previously reported in explaining cross-sectional variation in stock returns, by following the suggestions of Hoberg and Welch (2007). We document that the CAPM beta does a reasonable job in explaining the returns on CAPM-beta-sorted portfolios once we skip the first two years after portfolio formation.

We then examine the book-to-market effect which poses one of the greatest challenges to the CAPM. We find that the BM effect is driven by within-industry (rather than across-industry) variation in the book-to-market value of equity ratios. The within-industry BM effect disappears or significantly weakens once we control for firm-specific characteristics that proxy for real options available to a firm or when we measure the expected return using the Implied Cost of Capital (ICC). These findings are consistent with the view that the BM effect may in a large part be due to the option a firm has to modify/abandon existing projects and/or undertake new projects.

Finally, when we sort stocks according to proxies for real options, we find that while CAPM does not explain the average stock returns among firms that have significant numbers of real options, it does a reasonable job in explaining the stock returns among firms with few real options. This direct empirical evidence further support the view that the failure of CAPM in explaining the cross-section of stock returns is due to real options available to a firm. Overall, there is little evidence in the data to change one's prior beliefs that project cost of capital estimates provided by the CAPM are satisfactory.

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Table 1 Variable Definition

Variable	Definition
Beta	Slope of the CAPM regression, estimated in each June using the prior 60 months of returns from CRSP
Beta $_{aged}$	Aged beta, old Beta estimated using return data of two years prior to portfolio formation
Size	Market capitalization (in millions) measured at the last trading day of June
BE	Book value (in millions). If the data item of Compustat Data216 is not missing, then BE= Data216-Data10+Data35+Data79, otherwise BE =Data6-Data181-Data10+Data35+Data79. The data are further supplemented with historical equity data (Davis, Fama, and French, (2000)) from Ken French's website.
BM	Ratio of BE to Size
DE	Difference of total assets (Data6) and book value of equity (Data216), scaled by Size.
Turnover	Average monthly trading volume as a percentage of outstanding shares in the year prior to portfolio formation
Momentum	Cumulative stock returns in the year prior to portfolio formation
Capex	Ratio of capital expenditure (Data128) to sales (Data12).
Icov	Inverse interest coverage as the ratio of interest expense (Data15) to the operating income before depreciation (Data13).
BM_{fitted}	Predicted value generated in a cross-sectional OLS regression of the actual BM ratio on DE and Capex
Nayst	Number of analysts providing one-year-ahead earnings forecasts for a given firm in each June from I/B/E/S.
Grow	Long-term growth rate forecasts for a given firm in each June provided by I/B/E/S
$VWRET_i$	Average value-weighted monthly portfolio return in the *i*th year subsequent to portfolio formation
MKT, SMB, and HML	Fama-French three-factor. MKT is the CRSP value-weighted return on all stocks, SMB and HML are the size and value factors constructed by Fama and French, respectively.
Fama-French 10 industry classification	1 (Consumer NonDurables); 2 (Consumer Durables); 3 (Manufacturing); 4 (Energy); 5 (HiTec Business Equipment); 6 (Telcom); 7 (Wholesale, Retail, and some Services); 8 (Healthcare, Medical Equipment); 9 (Utilities); 10 (others)

Table 2 Beta-Sorted Portfolios

The sample consists of firms covered by CRSP monthly files, with the exclusion of firms with market capitalization less than the NYSE 10th percentile breakpoint, firms with a price of less than $5, firms with less than 36 monthly trading records in the prior 5 years, and firms in the deciles with the highest/lowest prior 12-month stock returns in each June of 1932-2007. Firms are sorted into portfolios by Beta in each June, rebalanced yearly. In Panels C and D, coefficient estimates are presented with *t* statistics in parentheses. Average absolute errors and GRS statistics are also presented. In Panel E, coefficient estimates are presented with *t* statistics in parentheses and Shanken *t* in brackets. The time series averages of MKT, SMB, and HML in the corresponding sample period are also presented.

Panel A

Portfolio Characteristics

	N	Beta	Size	BM	DE	Capex	Nayst	Grow	$Vwret_1$	$Vwret_2$	$Vwret_3$
High	107.30	2.09	795.99	0.78	1.39	0.19	9.69	0.20	1.21%	1.14%	1.17%
2	107.72	1.63	1,206.93	0.80	1.31	0.10	10.10	0.17	1.17%	1.14%	1.16%
3	107.87	1.41	1,464.17	0.79	1.36	0.16	10.57	0.16	1.11%	1.07%	1.15%
4	107.86	1.25	1,523.69	0.79	1.43	0.09	10.66	0.15	1.19%	1.06%	1.08%
5	107.63	1.12	1,451.04	0.80	1.50	0.07	10.36	0.14	1.22%	1.21%	1.12%
6	107.95	1.00	1,407.44	0.81	1.67	0.07	10.13	0.13	1.25%	1.12%	1.10%
7	107.93	0.88	1,515.97	0.82	1.89	0.07	9.92	0.13	1.22%	0.99%	1.09%
8	107.79	0.75	1,716.31	0.82	2.15	0.06	9.19	0.12	1.00%	0.93%	0.95%
9	107.80	0.60	1,420.27	0.84	2.46	0.07	8.89	0.11	1.03%	0.98%	0.93%
Low	107.42	0.36	1,079.54	0.87	2.01	0.11	9.09	0.09	0.99%	0.84%	0.90%

Panel B
Time Series Regressions: First-Year Monthly Returns Following Portfolio Formation

	intercept	MKT	adj R^2		intercept	MKT	SMB	HML	adj R^2
	-0.0038	1.62			-0.0046	1.51	0.3861	0.15	
High	(-3.33)	(73.72)	85.7%	High	(-4.40)	(67.87)	(11.67)	(5.04)	87.9%
	-0.0025	1.40			-0.0033	1.34	0.1541	0.20	
2	(-2.72)	(79.71)	87.5%	2	(-3.82)	(73.09)	(5.65)	(8.22)	88.8%
	-0.0017	1.24			-0.0024	1.21	0.0143	0.17	
3	(-2.25)	(82.97)	88.4%	3	(-3.18)	(76.77)	(0.61)	(8.31)	89.2%
	-0.0003	1.16			-0.0009	1.15	-0.0353	0.15	
4	(-0.45)	(81.02)	87.9%	4	(-1.18)	(75.42)	(-1.56)	(7.54)	88.6%
	0.0006	1.08			0.0001	1.08	-0.0977	0.15	
5	(0.81)	(79.14)	87.4%	5	(0.15)	(75.62)	(-4.58)	(8.03)	88.4%
	0.0016	0.99			0.0012	1.00	-0.1141	0.15	
6	(2.57)	(81.35)	88.0%	6	(1.98)	(79.21)	(-6.09)	(8.73)	89.3%
	0.0018	0.93			0.0012	0.94	-0.1322	0.20	
7	(2.70)	(71.44)	84.9%	7	(1.94)	(71.48)	(-6.78)	(11.48)	87.3%
	0.0007	0.79			0.0006	0.82	-0.1659	0.06	
8	(1.10)	(63.31)	81.6%	8	(1.01)	(62.83)	(-8.52)	(3.48)	83.1%
	0.0016	0.72			0.0014	0.76	-0.2132	0.10	
9	(2.13)	(50.87)	74.1%	9	(1.98)	(52.08)	(-9.85)	(5.23)	77.1%
	0.0023	0.57			0.0018	0.57	-0.1151	0.18	
Low	(3.07)	(38.48)	62.1%	Low	(2.46)	(37.17)	(-5.01)	(8.70)	65.7%
Average absolute error 0.0017				Average absolute error 0.0017					
GRS statistics 2.88				GRS statistics 3.23					
p-value *0.001*				p-value *0.000*					

Panel C

Time Series Regressions: Third-Year Monthly Returns Following Portfolio Formation

	Intercept	MKT	adj R^2		intercept	MKT	SMB	HML	adj R^2
	-0.0018	1.53			-0.0028	1.41	0.5198	0.18	
High	(-1.66)	(66.07)	83.2%	High	(-3.08)	(65.94)	(16.15)	(6.08)	87.4%
	-0.0005	1.31			-0.0011	1.23	0.3334	0.11	
2	(-0.56)	(71.79)	85.4%	2	(-1.45)	(69.12)	(12.43)	(4.28)	87.8%
	0.0003	1.18			-0.0007	1.16	0.1212	0.22	
3	(0.45)	(79.20)	87.7%	3	(-1.15)	(78.23)	(5.42)	(10.56)	89.4%
	0.0000	1.12			-0.0010	1.15	-0.0739	0.23	
4	(-0.02)	(77.07)	87.1%	4	(-1.59)	(79.16)	(-3.39)	(11.33)	88.8%
	0.0009	1.05			0.0003	1.07	-0.0559	0.14	
5	(1.47)	(77.07)	87.1%	5	(0.51)	(75.55)	(-2.62)	(7.18)	87.9%
	0.0012	0.98			0.0004	1.03	-0.1549	0.19	
6	(1.95)	(72.79)	85.7%	6	(0.77)	(77.15)	(-7.74)	(10.16)	87.9%
	0.0015	0.92			0.0010	0.96	-0.1875	0.14	
7	(2.34)	(66.64)	83.4%	7	(1.64)	(70.20)	(-9.06)	(7.01)	85.5%
	0.0008	0.81			0.0006	0.86	-0.2140	0.08	
8	(1.30)	(59.15)	79.9%	8	(0.98)	(62.77)	(-10.32)	(4.01)	82.3%
	0.0010	0.75			0.0006	0.82	-0.2743	0.14	
9	(1.47)	(48.47)	72.7%	9	(0.85)	(54.57)	(-12.16)	(6.73)	77.6%
	0.0017	0.60			0.0013	0.65	-0.1731	0.12	
Low	(2.28)	(36.29)	59.9%	Low	(1.77)	(37.77)	(-6.71)	(4.85)	62.7%
Average absolute error 0.0010				Average absolute error 0.0010					
GRS statistics 1.37				GRS statistics 1.41					
p-value *0.190*				p-value *0.171*					

Panel D

Fama-MacBeth Cross-sectional Analysis

	First-year Monthly Return		Third-year Monthly Return		Average Factor Return
	Model 1	Model 2	Model 1	Model 2	
Intercept	0.0063	0.0026	0.004	0.0024	
	(4.14)	(1.23)	(2.39)	(1.04)	
	[4.14]	[1.18]	[2.39]	[1.03]	
MKT	0.0019	0.0041	0.0033	0.0048	0.0067
	(0.84)	(1.61)	(1.46)	(1.63)	
	[0.67]	[1.30]	[1.27]	[1.44]	
SMB	-	-0.0041	-	-0.006	0.0021
		(-1.44)		(-0.31)	
		[-1.29]		[-0.27]	
HML	-	0.0082	-	0.0002	0.0042
		(1.83)		(0.03)	
		[1.70]		[0.03]	
adj R^2	38.8%	54.88%	80.99%	80.63%	

Table 3 Fama-French Industry Portfolios Sorted by BM

Panel A: 30 Industry-BM Portfolios

First, firms are sorted into 10 portfolios by the Fama-French 10 industry classification in each June. Within each industry portfolio, firms are further categorized into terciles by BM. Asset pricing tests are conducted on the value-weighted monthly portfolio returns in the first year of these 30 portfolios. Average absolute errors and GRS statistics of the time-series analysis, as well as coefficient estimates from the cross-sectional analysis (with *t* statistics in parentheses and Shanken *t* statistics in brackets) are presented. The time series averages of the factors MKT, SMB, and HML in the corresponding sample period are also presented.

Time Series Regression Analysis		
	CAPM	FF 3 Factor
Absolute pricing error	0.0017	0.0019
GRS statistics (p-value)	2.27 (0.00)	2.76 (0.00)

Cross-sectional Analysis			
	CAPM	FF 3 Factor	Average Factor Return
Intercept	0.0034 (1.76) [1.75]	0.005 (2.41) [2.39]	
MKT	0.0058 (2.22) [1.85]	0.0038 (1.41) [1.18]	0.0067
SMB	-	0.0041 (1.98) [1.72]	0.0021
HML	-	0.0017 (1.11) [0.88]	0.0042
adj R^2	32.51%	35.91%	

Panel B Ten Fama-French Industry Portfolios with Maximum BM Dispersion: Portfolio Characteristics

Firms are first sorted into 10 portfolios by the Fama-French 10 industry classification in each June. Within each industry portfolio, firms are further sorted into three portfolios based on their BM. Within each industry we pick one of the BM sorted portfolios so that the ten industry portfolios we finally arrive at exhibit the maximum dispersion in the BM characteristic across the ten portfolios.

Industry	Nos	Beta	Size	BM	DE	Capex	Nayst	Grow	$Vwret_1$
1	33.76	1.00	404.58	1.87	1.32	0.04	6.20	0.12	1.36%
2	12.74	1.27	990.08	1.68	1.53	0.04	6.56	0.12	1.33%
3	88.63	1.18	783.84	0.88	0.70	0.06	8.38	0.13	1.30%
4	14.58	1.12	1,498.76	2.12	1.15	0.23	13.16	0.13	1.93%
5	19.77	1.50	509.64	1.56	1.48	0.08	8.10	0.16	1.68%
6	5.42	1.19	3,111.33	2.19	1.37	0.25	12.61	0.12	1.42%
7	38.11	1.03	2,089.68	0.44	0.43	0.04	12.66	0.18	1.12%
8	31.57	1.06	2,953.64	0.34	0.22	0.12	14.29	0.21	1.20%
9	13.82	0.81	1,698.42	0.52	1.13	0.11	11.95	0.13	0.81%
10	96.07	1.19	798.73	2.85	6.17	0.07	8.47	0.12	1.27%

Panel C: Ten Fama-French Industry Portfolios with Maximum BM Dispersion:
Time Series Regression Analysis

Regression coefficient estimates are presented with *t* statistics in parenthesis. Average absolute errors and GRS statistics are also presented.

Industry	Intercept	MKT	adj R^2	Industry	Intercept	MKT	SMB	HML	adj R^2
	0.0025	1.02			0.0006	0.88	0.3217	0.45	
1	(2.09)	(44.14)	68.3%	1	(0.62)	(40.88)	(10.05)	(15.67)	77.2%
	0.0009	1.19			-0.0006	1.07	0.3117	0.32	
2	(0.46)	(32.95)	54.5%	2	(-0.31)	(28.02)	(5.49)	(6.33)	57.8%
	0.0002	1.23			-0.0012	1.16	0.0641	0.38	
3	(0.22)	(66.07)	82.8%	3	(-1.39)	(64.38)	(2.39)	(15.68)	86.6%
	0.0066	1.20			0.0035	1.08	0.0205	0.88	
4	(2.84)	(26.61)	43.9%	4	(1.64)	(24.17)	(0.31)	(14.80)	54.8%
	0.0028	1.33			0.0012	1.17	0.4531	0.34	
5	(1.49)	(36.11)	59.0%	5	(0.69)	(30.71)	(8.00)	(6.73)	63.5%
	0.0001	1.22			-0.0023	1.11	0.0530	0.67	
6	(0.06)	(27.73)	45.9%	6	(-1.08)	(24.60)	(0.79)	(11.11)	52.4%
	0.0025	0.80			0.0034	0.89	-0.2529	-0.19	
7	(1.97)	(32.51)	53.9%	7	(2.77)	(34.38)	(-6.57)	(-5.63)	57.4%
	-0.0019	0.80			-0.0017	0.80	0.0497	-0.08	
8	(-0.97)	(21.15)	33.1%	8	(-0.84)	(19.30)	(0.80)	(-1.46)	33.1%
	-0.0012	1.01			-0.0010	1.04	-0.0721	-0.05	
9	(-1.31)	(57.44)	78.5%	9	(-1.05)	(53.98)	(-2.51)	(-1.90)	78.7%
	0.0029	0.52			0.0041	0.58	-0.0465	-0.32	
10	(1.78)	(16.52)	23.2%	10	(2.57)	(17.21)	(-0.93)	(-7.20)	27.3%
Average absolute error 0.0022				Average absolute error 0.0019					
GRS statistics 3.03				GRS statistics 2.65					
p-value *0.001*				p-value *0.003*					

Panel D: Ten Fama-French Industry Portfolios with Maximum BM Dispersion: Cross-sectional Analysis

Coefficient estimates are presented with *t* statistics in parentheses and Shanken *t* statistics in brackets. The time series averages of the factors MKT, SMB, and HML in the corresponding sample period are also presented.

	Model 1	Model 2	Average Factor Return
Intercept	0.0006	0.0073	
	(0.23)	(2.35)	
	[0.23]	[2.31]	
MKT	0.0088	0.0008	0.0067
	(2.76)	(0.22)	
	[2.40]	[0.20]	
SMB	-	0.0010	0.0021
		(0.30)	
		[0.28]	
HML	-	0.0062	0.0042
		(2.57)	
		[2.28]	
Adj R^2	45.16%	51.65%	

Table 4 BM Effects within Industry

Panel A Within Industry BM-sorted Portfolios

Firms are first put into 10 portfolios according to the Fama-French 10 industry classification in each June. Within each industry firms are sorted into deciles by BM. Firms in each of the BM deciles within an industry are then merged firms in the corresponding BM deciles in other industries to give ten within industry BM sorted portfolios of firms.

BM	nos	Beta	Size	BM	DE	Capex	Nayst	Grow	$Vwret_1$	$Vwret_2$	$Vwret_3$
High	109.79	1.11	710.65	1.81	3.34	0.08	7.92	0.12	1.32%	1.18%	1.24%
2	114.68	1.05	894.22	1.23	2.55	0.08	8.95	0.13	1.14%	1.22%	1.18%
3	115.58	1.05	1,097.83	1.03	2.15	0.08	9.07	0.13	1.09%	1.15%	1.21%
4	114.86	1.04	1,314.35	0.88	2.09	0.08	9.45	0.13	1.06%	1.07%	1.03%
5	113.56	1.02	1,396.40	0.78	1.81	0.07	9.70	0.13	1.10%	1.20%	1.03%
6	116.68	1.04	1,608.65	0.68	1.57	0.08	9.93	0.14	0.96%	1.10%	1.15%
7	115.86	1.04	2,073.81	0.59	1.33	0.08	10.70	0.14	1.03%	1.01%	1.06%
8	114.58	1.06	2,654.20	0.50	1.06	0.09	11.35	0.15	1.00%	0.98%	1.01%
9	115.68	1.08	3,269.22	0.40	0.70	0.13	11.41	0.16	0.91%	1.02%	0.99%
Low	110.82	1.11	3,698.76	0.22	0.51	0.23	11.23	0.18	0.92%	0.94%	0.98%

Panel B Within Industry DE/BM -sorted Portfolios

Firms are put into 10 portfolios based on the Fama-French 10 industry classification in each June. Firms within each industry are further double-sorted into terciles first by DE and then by BM.

DE	Beta			Size			BM		
	L	M	H	L	M	H	L	M	H
L	1.10	1.08	1.04	3,484.22	1,896.90	835.68	0.29	0.51	0.85
M	1.07	1.03	1.06	3,275.60	1,589.36	897.05	0.49	0.76	1.17
H	1.05	1.02	1.08	2,386.43	1,506.41	887.34	0.64	1.01	1.64
	DE			Capex			Nayst		
L	0.23	0.33	0.37	0.19	0.12	0.10	11.37	10.43	8.41
M	1.09	1.09	1.05	0.11	0.08	0.08	12.01	10.22	8.82
H	2.94	3.52	4.83	0.09	0.06	0.06	10.52	9.48	8.47
	Grow			Rdisp			$Vwret_1$		
L	0.18	0.16	0.15	3.96	4.42	5.41	0.93%	0.89%	0.99%
M	0.14	0.13	0.13	4.17	4.63	5.83	1.04%	1.00%	1.02%
H	0.13	0.12	0.11	4.68	5.22	6.34	1.07%	1.20%	1.41%

Panel C: Cross-sectional Regression

The left side variable is the average monthly return for a stock for a given year. The right side variables are the various stock characteristics. We focus on within-industry variations by first demeaning all the variables within industry. We apply log-transformation to Size, BM and DE. The regression coefficients are then averaged across time and the t-values are computed using the Fama-MacBeth procedure, and the Newey-West formula with a lag of 6 months.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
$Beta_{aged}$	-	0.0058	-	0.0061	0.0061	0.0060	0.0053
		(0.55)		(0.58)	(0.59)	(0.57)	(0.51)
Size	-	-0.0101	-	-0.0087	-0.0090	-0.0087	-0.0086
		(-2.27)		(-2.00)	(-2.06)	(-2.01)	(-1.97)
DE	-	0.0122	-	0.0074	0.0075	0.0076	0.0078
		(3.47)		(1.51)	(1.52)	(1.53)	(1.58)
Capex	-	-0.0785	-	-0.0792	-0.0780	-0.0799	-0.0782
		(-2.97)		(-3.07))	(-2.99)	(-3.18)	(-3.01)
BM	0.0313	-		0.0150			
	(5.78)			(1.95)	-	-	-
BM_{fitted}	-	-	0.0509	-			
			(5.06)		-	-	-
BM*(Small Stock)	-	-	-	-	0.0218		
					(2.99)	-	-
BM*(Large Stock)	-	-	-	-	0.0054		
					(0.59)	-	--
BM*(Low DE)	-	-	-	-	-	0.0118	
						(1.04)	-
BM*(High DE)	-	-	-	-	-	0.0173	
						(2.22)	-
BM*(Low Icov)	-	-	-	-	-		0.0082
							(0.92)
BM*(High Icov)	-	-	-	-	-		0.0224
							(3.02)
R_{adj}^2	1.65%	4.89%	1.85%	5.73%	5.81%	5.87%	5.87%

Table 5 Implied Cost of Capital

The implied cost of capital (ICC) estimates and the corresponding analyst forecasts used to impute the ICCs are presented for 10 within-industry BM-sorted portfolios. For each of the 10 portfolios, the earnings and dividend payout data are aggregated across firms, and the ICC is computed as the rate at which the portfolio value equates the present value of future dividends, computed following the procedure in Pastor, Sinha and Swaminathan (2007). FE_1, FE_2, and Ltg is the median one-year-ahead, two-year-ahead, and long-term earnings growth analyst forecast respectively, provided by I/B/E/S. The plow-back rate (b) is a firm's most recent net payout ratio (as sum of dividends and stock repurchased, scaled by the net income) from Compustat. We use the historical GNP growth as the steady state earnings growth rate Ltg_{ss}. The steady state payout ratio b_{ss} is imputed as the ratio of the GNP growth rate over ICC.

BM	FE_1	FE_2	Ltg	Ltg_{ss}	b	b_{ss}	ICC
High	0.0802	0.1031	10.87%	6.69%	68.35%	62.82%	11.44%
2	0.0873	0.1035	10.05%	6.69%	67.84%	62.82%	11.24%
3	0.0831	0.0982	10.84%	6.69%	68.56%	63.76%	11.14%
4	0.0840	0.0989	11.76%	6.69%	69.24%	61.92%	11.51%
5	0.0818	0.0938	11.11%	6.69%	65.89%	63.80%	11.03%
6	0.0788	0.0906	11.84%	6.69%	68.21%	63.67%	10.94%
7	0.0747	0.0857	12.03%	6.69%	63.90%	64.70%	10.78%
8	0.0701	0.0811	13.46%	6.69%	65.21%	64.04%	10.82%
9	0.0660	0.0758	13.46%	6.69%	61.18%	66.20%	10.47%
Low	0.0540	0.0638	16.08%	6.69%	65.82%	70.38%	9.89%

Table 6 Cross-sectional Regression on Portfolios Sorted by Capex

Results of the Fama-MacBeth cross-sectional analysis are presented for the sample firms in the top and bottom deciles sorted by Capex. One-year average stock returns are regressed on various stock characteristics each year. The regression coefficients are then averaged across time and the t-values are computed using the Newey-West formula with a lag of 6 months. Log-transformation is applied to Size, BM and DE.

Capex	$Beta_{age}$	Size	BM	DE	Momentum	Turnover	R_{adj}^2
	0.0423	-	-	-	-	-	3.76%
	(1.82)						
Lowest	0.0469	-0.0123	0.0433	-	-	-	8.17%
	(2.27)	(-1.99)	(3.08)				
	0.0537	-0.0109	0.0537	0.0019	0.0595	-0.7201	13.89%
	(3.88)	(-2.01)	(3.72)	(0.26)	(1.71)	(-1.53)	
	0.0075	-	-	-	-	-	5.45%
	(0.23)						
Highest	0.0126	-0.0053	0.0039	-	-	-	9.93%
	(0.44)	(-0.87)	(2.27)				
	0.030	-0.0036	0.0051	-0.0250	0.0617	-0.1821	16.05%
	(1.07)	(-0.60)	(3.76)	(-2.14)	(1.47)	(-0.60)	