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Are Equities Real(ly) Options? Understanding the Size, Book-to-Market and Earnings-to-Price Factors

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Abstract

We model the value of a firm facing irreversible investment opportunities as a portfolio of real call options: options to invest and options to produce. Theory predicts that the expected return on the firm's equity is dependent on (i) the CAPM beta of the assets underlying the options; and (ii) the average elasticity of the options. The average option elasticity depends on volatility, the level of demand and the degree of excess capacity. Our analysis, based on a large scale simulation experiment, confirms these predictions. Additionally we show that the factors analyzed by Fama and French (1992) - beginning-of-period market value of equity, book-to-market equity and earnings-to-price - are strongly associated with the CAPM beta of the underlying assets, volatility, the level of demand and the degree of excess capacity. The links to (unobservable) model fundamentals provide a clear economic rationale for the Fama and French risk factors, but they do not require an appeal to the pricing of bankruptcy risk.

In this paper we suggest reasons why factors other than the capital asset pricing model (CAPM) beta will explain cross-sectional variation in stock returns. We model the value of a firm's equity as a portfolio of real call options - options to use productive capacity and options to invest in new productive capacity. Option values derive both from investment irreversibility and the opportunity, but not compulsion, to produce output. The expected return on a firm's equity is the expected return on the portfolio of real call options. The risk premium for a call option depends on the expected return of the underlying asset and on the option elasticity (Cox and Rubinstein, 1985, pp.224-228). *We assume that expected returns on a firm's underlying assets are determined by the CAPM and that stocks are priced rationally in a market with full information.* In this setting we show that empirically observable variables such as the market value of equity (ME), the equity book-to-market value (BE/ME) and the earnings-to-price ratio (E/ME) can be expected to serve as proxies for the unobservable fundamental determinants of option portfolio expected returns: underlying asset CAPM beta, average option elasticity and the balance in the portfolio between investment options and productive assets in place.

There is considerable empirical evidence contradicting the linear relation between expected excess returns and beta predicted by the Sharpe (1964), Lintner (1965) and Black (1972). Prior research has shown that returns are explained by a variety of factors including earnings-to-price (Basu, 1983), size (Banz, 1981), cash flow-to-price (Rosenberg, Reid and Lanstein, 1985), book-to-market equity (Fama and French, 1992) and past sales growth (Lakonishok, Shleifer and Vishny, 1994). Fama and French (1992) find that ME and BE/ME capture a large proportion of cross-sectional returns variation and appear to dominate the estimated CAPM beta in explaining returns. Furthermore, Fama and French (1996a) show that a three-factor model including ME and BE/ME, in combination with beta, subsumes most of the other documented explanatory factors for average returns.

A majority of the research attempting to explain the empirical failure of CAPM focuses on the possibility that biases in beta measurement, sample selection and sample survivorship are important (e.g. Kothari, Shanken and Sloan, 1995; Breen and Korajczyk, 1993). Although Kothari, Shanken and Sloan (1995) report evidence suggesting that survivorship bias is influential, they do not claim that it can fully explain the empirical rejection of CAPM. Fama and French (1996b) suggest that, in any case, the rejection of CAPM appears robust to research design biases. Alternatively, Jagannathan and Wang (1996) suggest that a respecification of the CAPM, to one in which betas are dependent upon conditioning information, can explain the BE/ME effect in empirical cross-sectional regressions. However, these studies do not establish a clear economic role for BE/ME, or other variables such as size, as determinants of returns.

Fama and French (1995, 1996a) suggest that BE/ME is a proxy for risk associated with financial distress, but they acknowledge that the theoretical basis for a distress premium is weak. Furthermore, Dichev (1998) finds evidence against bankruptcy risk being a source of systematic risk. Fama and French (1996a) explore the possibility that size and BE/ME proxy for sensitivity to common risk factors. Using a model in which earnings play a fundamental valuation role, they find that the market and size factors in earnings are related to those in returns, but that the BE/ME factor is not. Therefore, an explanation of the role of BE/ME as a risk premium remains elusive.

The research approach adopted in this paper is similar in spirit to the analytical modelling approaches of Berk (1995) and Berk, Green and Naik (1998) in which the ME and BE/ME effects emerge as natural consequences of an economic model. Berk (1995) considers an economy in which firms are characterized by their payoff at the end of the period and expected return. These features of firms are then modelled as being independent random draws from a (cross-sectional) probability distribution. Berk demonstrates that this is sufficient to induce a negative relationship between ME and expected return, independent of the process generating expected returns. Berk, Green and Naik (1998) analyze a dynamic optimizing model of a firm facing a world of stochastic interest rates. New investment projects arise regularly, but the required initial investment and risk is random. If a project is not accepted when it arises, it dies. Once accepted, a project's life is also random. From this basic economic structure an expression for the firm's expected return is derived as a function of BE/ME, amongst other variables.

In this paper we use a conceptually simple model, developed from Pindyck (1988). Firms are assumed to take optimal investment and production decisions under conditions of uncertainty and investment irreversibility. They hold options to add productive capacity at any time they wish without limit. All investments in productive capacity are funded by new equity investment. Once made, an investment in productive capacity is irreversible - we assume it has no value in alternative use. Nonetheless, the firm does not produce compulsively - it has the option to costlessly shut down productive capacity should it be more profitable to produce below capacity. In this setting, valuable real options exist because firms can defer irreversible investments (the investment option) and shut-down production capacity when profit maximizing output is lower than capacity (the production option).

The firm's equity is valued as a portfolio of production and investment options, under the maintained assumption that the value of each real option possessed by the firm is determined by the same fundamental state variable (a variable describing the demand conditions facing the firm). Further, we make the standard assumption in contingent claims analysis that, for each firm, there exists an asset that is perfectly correlated with the underlying state variable. We assume that the returns on this asset are determined by a single-factor, CAPM-type generating process. As a consequence, each of the firm's real options can be valued using contingent claims analysis.

Our research design is as follows. We employ simulation methods to create a universe of hypothetical firms, using the model outlined above. Equity returns are linked in cross-section by a single factor that influences the evolution of each firm's underlying state variable. We investigate how empirically observable variables, such as ME, BE/ME and E/ME reflect the unobservable fundamental determinants of the value and expected returns of real options owned by firms. The fundamental factors include asset beta, volatility, the level of the state variable and a measure of capacity utilization. We also show that portfolios sorted on ME, BE/ME and E/ME strongly capture cross-sectional variation in the fundamental variables.[1]

The second stage of our investigation focuses on the role of ME, BE/ME and E/ME in determining the distribution of stock returns. Our simulation-based analysis suggests that ME, BE/ME and E/ME may explain expected returns because they proxy for fundamental features that determine expected returns. Analysis of simulated data portfolios confirms that ME, BE/ME and E/ME have, respectively, negative, positive and positive relationships with one-period ahead average portfolio returns. These relationships are confirmed in univariate regressions of individual returns on these variables. When we rank firms on a two-dimensional basis (first by ME and, then, within ME quintiles by BE/ME), the results confirm those in Fama and French (1992), i.e. average portfolio returns decrease as ME increases and, within ME portfolios, increase as BE/ME increases. Further, multivariate regressions of returns on the three variables generally produce similar qualitative results to those found in empirical data.

The remainder of the paper is organized as follows. Section 1 describes our dynamic model of an individual firm. Section 2 provides the details of our simulations. Section 3 presents simulation results describing the relations between returns, ME, BE/ME, E/ME and the fundamental characteristics of firm's real options. Section 4 reports simulation results on the association between one-period ahead returns and ME, BE/ME and E/ME. Section 5 contains our conclusions and implications for future research.

1. The Firm as a Portfolio of Real Options

1.1. Intuition

We view the firm as a portfolio of assets in place (i.e. current productive capacity) and investment opportunities (i.e. potential future productive capacity). The important dimension of our valuation model, when compared with most prior research on equity valuation, is the recognition that the values of both assets in place and future investment opportunities reflect the values of real options.

We focus on two types of real options, both resulting from investment irreversibility. First, the firm must decide on the profit maximizing production level, subject to a capacity constraint resulting from prior investment decisions. Production decisions involve the exercise of call options over units of productive capacity, the exercise price being the variable cost of production.

Second, when evaluating opportunities to invest in new productive capacity, firms are assumed to be able to exercise discretion over the timing of investments. Timing options can also be represented as call options, the exercise price being the investment outlay and the value of the asset being derived from the operating cash flows resulting from future optimal production decisions. Both production options and investment timing options are potentially very significant components of total firm value (Pindyck 1988; Dixit and Pindyck 1994).

It is important to recognize that a firm that follows an optimal investment strategy *ex ante* may appear to have installed too much capacity *ex post* because demand is stochastic. Product demand can reach critical values that trigger new investment, but it can also drift downwards. When this happens it may be optimal for the firm to produce at below full capacity. In this situation the value of the option to wait exceeds the value of the marginal unit of capacity in use, net of the investment outlay. However, by investing in the marginal unit of capacity at some earlier date, the firm has forgone this option. Because of investment irreversibility, the value to the firm of the marginal unit of excess capacity will be less than the value of the option to invest in that unit.

The expected return for the aggregate firm will be a value-weighted average of the expected returns on all options in the firm's portfolio. Option pricing theory can help in understanding the determinants of the firm's expected return, given our simple characterization of the firm. It is well-known that the expected excess return on a single call option is equal to

$$E(r_j - r) = \Omega_j E(r_a - r) \tag{1}$$

where r_j is the return on the call option, Ω_j is the elasticity on the call option, r_a is the return on the underlying asset, and r is the risk-free rate of interest (see, for example, Cox and Rubinstein 1985). Note that the elasticity of a call option (and, hence, its expected return) is a decreasing (non-linear) function of in-the-moneyness and of volatility.

If expected returns on the underlying asset are generated according to the CAPM, equation (1) can be combined with the CAPM to give

$$E(r_j - r) = \Omega_j \beta_j E(r_m - r) \tag{2}$$

where β_j is the underlying asset's CAPM beta and $E(r_m - r) > 0$ is the expected market risk premium. Thus, if the firm is effectively a portfolio of options, its expected return, $E(R)$, will be the risk-free rate of interest plus a value weighted average of elasticity-adjusted expected asset excess returns, i.e.:

$$E(R) = r + \sum_j w_j \Omega_j \beta_j [E(r_m - r)] \tag{3}$$

where w_j is the value of the $j'th$ real option. Equation (2) suggests that, *ceteris paribus,* firms with higher option-related components of value and higher option elasticities will have higher expected equity returns.

Within this structure, expected returns will depend on the balance between production and investment options. We expect that the levels of the demand and capacity utilization will act as proxies for the average degree of moneyness for options held by the firm and for the balance between production and investment options. *Ceteris paribus*, we would expect capacity utilization to have a negative relationship with expected returns - production and investment options will move out of the money and have higher elasticities as capacity utilization declines.

1.2. Model Structure

Our model of the firm is based on Pindyck (1988). Specifically, consistent with Pindyck (1988), we assume the following:

1. the firm can invest in infinite-lived, non-depreciating, units of capacity;
2. investment is irreversible;[2]
3. the cost of all units of capacity is exogenous and constant for each unit and over time (and equals k);
4. each unit of capacity can produce a single unit of output per period;
5. the firm holds no inventories, receivables or payables - it has no working capital;
6. all new investment is financed by equity and all profits are fully distributed.[3]

The value of assets in place depends on the expected profitability of production. We assume that the profitability of a firm's product depends on the realization of a state variable, θ, which can be thought of as an exogenously determined demand shift parameter. Thus, the demand function for the firm's output is as follows:

$$P(t) = \theta(t) - \gamma Q \tag{4}$$

where $P(t)$ is the price of output at time t, Q is amount produced and sold, γ is a non-negative constant and $\theta(t)$ is the random state variable. If $\gamma = 0$, $\theta(t)$ can be re-interpreted as the exogenous price at which the firm's product sells in a perfectly competitive market at time t.

The state variable $\theta(t)$ evolves according to the following stochastic process:

$$d\theta = \alpha\theta dt + \sigma\theta dz \tag{5}$$

where dz is the increment of a Wiener process and α and σ are constants.

Pindyck (1988) assumes that there exists an asset or portfolio of assets that is perfectly correlated with θ. The expected rate of return on this asset or portfolio of assets is equal to:

[2] One way of motivating irreversibility is to consider each unit of capacity as having no value in any alternative use. Dixit and Pindyck (1994, Ch.7) consider the case of partially reversible investment. Generally, they show that the value of investment options decreases as reversibility increases. Nonetheless, we do not expect that our main conclusions would be affected unless investment is totally reversible - that is, partial reversibility would lead to similar qualitative conclusions.

[3] The model runs using a discrete time approximation to continuous time. We assume, however, that dividends are paid annually.

$$\mu = r + \beta(r_m - r) \tag{6}$$

where β is the CAPM beta of the assets or portfolio of assets.

The firm's operating cost function is given by:

$$C(Q) = c_1 Q + c_2 Q^2/2 \tag{7}$$

with $c_1, c_2 \geq 0$.

At all points in time (including $t = 0$) the firm solves two problems. Having observed the value of $\theta(t)$, first it decides on whether further investment is necessary,[4] and, second, it decides on how much to produce, given the chosen level of investment.

1.2.1. *The Investment Problem*

The firm's investment problem involves first finding the optimal capacity level, K, defined where the present value of the marginal unit of capacity is just equal to the value of the option to invest, plus the exercise price (the cost of the capacity). This requires that, each period, the firm compares the realized value of θ with critical threshold values of θ established for each unit of capacity. If θ is less than the threshold $\theta^*(K)$ it is not optimal to add the $K+1'th$ unit of capacity; and if θ is above the threshold it is optimal to add the $K+1'th$ unit of capacity. Whether the optimal capacity level is feasible will depend on whether θ has previously been at a level higher than the current optimal threshold value. If this is the case then the firm will avoid further investment and may have to consider operating at below full capacity.

1.2.2. *The Production Problem*

At time t the firm owns a specific number of units of capacity, $K(t)$. The firm's production problem is to select the output level to maximize profits, $\pi(t)$, subject to the capacity constraint:

$$\max_{Q} \pi(t) = (\theta(t) - c_1)\, Q - \left(\gamma + \frac{c_2}{2}\right) Q^2 \tag{8}$$

subject to: $0 \leq Q \leq K(t)$.

[4] At time $t = 0$, no investment has taken place. Hence, in this context further investment is initial investment.

1.2.3. *Firm Valuation*

Given the above, Pindyck (1988) shows that the value of a marginal unit of capacity is a complex non-linear function of θ, the volatility of θ, and the risk-adjusted cost of capital of the underlying asset, amongst other variables. Specifically, Pindyck (1988) shows that if $\Delta V(K,\theta)$ is the value of installing the marginal unit of capacity, given K units have already been installed and the state variable takes the value θ, then:

$$\begin{array}{ll} \Delta V(K,\theta) = b_1\theta^{\beta_1}; & \text{if } \theta \leq (2\gamma + c_2)K + c_1 \\ \Delta V(K,\theta) = b_2\theta^{\beta_2} + \theta/\delta - [(2\gamma + c_2)K + c_1]/r; & \text{if } \theta > (2\gamma + c_2)K + c_1 \end{array}$$

where:

$$\begin{array}{l} \delta = \mu - \alpha \\ \beta_1 = [-(r-\delta-\sigma^2/2)^2 + [(r-\delta-\sigma^2/2)^2 + 2r\sigma^2]^{(.5)}]/\sigma^2 \\ \beta_2 = [-(r-\delta-\sigma^2/2)^2 + [(r-\delta-\sigma^2/2)^2 + 2r\sigma^2]^{(.5)}]/\sigma^2 \\ b_1 = [r - \beta_2(r-\delta)][(2\gamma + c_2)K + c_1]^{(1-\beta_1)}/[r\delta(\beta_1 - \beta_2)] \\ b_2 = [r - \beta_1(r-\delta)][(2\gamma + c_2)K + c_1]^{(1-\beta_2)}/[r\delta(\beta_2 - \beta_1)] \end{array} \quad (9)$$

The solution for $\Delta V(K,\theta)$ can be interpreted as follows. When $\theta \leq (2\gamma + c_2)K + c_1$, the unit of capacity is not in use with the current value of θ. Therefore, the value of the unit of capacity represents the option to produce in the future. If $\theta > (2\gamma + c_2)K + c_1$, the value of the unit of capacity is in two parts. $\theta/\delta - [(2\gamma + c_2)K + c_1]/r$ represents the value of always producing and $b_2\theta^{\beta_2}$ represents the value of the option to temporarily and costlessly suspend production.

When investment is irreversible, the option to wait, i.e. to defer investment, can be a particularly valuable component of overall firm value. Pindyck (1988) also shows that $\Delta F(K,\theta)$, the value of the option to invest in a marginal unit of capacity, given that K units have already been installed and the state variable takes the value θ, is given by:

$$\begin{array}{ll} \Delta F(K,\theta) = a\theta^{\beta_1}; & \text{if } \theta \leq \theta^*(K) \\ \Delta F(K,\theta) = \Delta V(K,\theta) - k; & \text{if } \theta > \theta^*(K) \end{array}$$

where a is given by:

$$a = [b_2\beta_2\theta^{(\beta_2-\beta_1)}/\beta_1] + [\theta(K)^{(1-\beta_1)}/\delta\beta_1] \quad (10)$$

$\theta^*(K)$ is the solution to:

$$0 = [b_2(\beta_2 - \beta_1)\theta(K)^{(\beta_2)}/\beta_1] + [(\beta_1 - 1)\theta(K)/\delta\beta_1] - [(2\gamma + c_2)K + c_1]/r - k \quad (11)$$

If $\theta > \theta^*(K)$, the value of the option to invest is equal to the net present value of the unit of capacity in place. Otherwise it is valued as an option to invest some time in the future.

A value-maximizing firm will invest in units of capacity as long their value in use exceeds the investment outlay plus the value of the option to invest later. Conditional on the level of θ, the optimal level of installed capacity will satisfy this requirement.

The value of the firm at any time t is then found by summing the values of all the assets in place, $\Delta V(K, \theta(t)), K \leq K(t)$ and the values of all the remaining options to invest, $\Delta F(K, \theta(t))$, $K > K(t)$, where $K(t)$ is the level of installed capacity at time t and $\theta(t)$ is the level of the state variable at time t.[5] We use the valuation formula in Pindyck (1988). Thus, the market value at time t, $MV(t)$, is calculated as:

$$MV(t) = \sum_{0}^{K(t)} \Delta V(K, \theta(t)) + \sum_{K(t)+1}^{\infty} \Delta F(K, \theta(t)) \tag{12}$$

Relating this model of the firm to the intuition above, if investment is irreversible and if demand is volatile, we expect the options (i) to use productive capacity; and (ii) to wait to invest, to be the two components of the overall value of the firm. In turn, expected returns will be a complicated (non-linear) function of the fundamental model parameters, including the moneyness of the embedded real options (reflected by the level of the state variable, θ and capacity utilization), volatility and the CAPM beta of the underlying assets. We expect observable "output" variables such as ME, BE/ME, and E/ME to depend on the same fundamentals. As a consequence we would expect to observe relationships between expected return, ME, BE/ME, and E/ME. Figure 1 summarizes the logic of our approach.

[5] Note that the market value at any time t will, in part, depend on the path that θ has taken to get to its current value. This is because the path taken will affect the current level of capacity. Different paths can produce different current levels of capacity. Further, market value, for a given θ, will depend upon the current level of capacity. Thus, the market return over a period will depend on not just the end-points of the path of θ over the period but also the path taken which will affect the profits fully paid out as dividends, the investment paid for by new equity and the closing market value of the firm.

2. The Simulation Experiment

Although Pindyck's (1988) analysis provides expressions for the values of marginal units of capacity, no tractable closed-form solution can be derived from the model which would enable us to calculate the overall value of the firm, the overall effective elasticity associated with the real options, or the overall expected return. Therefore we conduct a computational experiment, based on Monte Carlo simulation methods, to gain further insights into how equity returns evolve and relate to model fundamentals and to empirically observable variables such as ME, BE/ME and E/ME.

We base our simulation experiments on 10,400 simulated firm-histories, each of 25 years in length. We adopt a discrete time approximation, assuming time increments of "one day" and aggregating all flow variables assuming 250 days in a year. The simulation population comprises a set of one hundred firm-histories generated for each of 104 different combinations of asset beta parameter values (β ranges from 0 to 1.2 in steps of .1) and volatility parameter values (σ ranges from .15 to .22 in steps of .01).

Each "day" a simulated firm is assumed to solve the optimal investment problem[6] and the optimal production problem, conditional on the value of θ observed on that day. Thus, each firm simulation produces 6,250 "daily" values for capital investment, output volume and capacity, the market value of assets in place and growth options, and profit and book value.[7]

We ensure consistency between CAPM and the volatility structure of our model by defining the total volatility of θ for a firm as:

$$\sigma^2 = \beta^2 \sigma_m^2 + \sigma_\varepsilon^2 \tag{13}$$

where σ_m^2 is the systematic component of volatility θ, and σ_ε^2 is the firm-specific "idiosyncratic" component of volatility in θ. The systematic component of volatility implied by equation (13) is simulated once for each "day" of the simulations and applies to all firms. The idiosyncratic component of the volatility of θ in this equation is simulated for each individual firm and for each individual firm "day".

The basic accounting period is assumed to be one year. Year end book value is

[6] In the simulation models we set an arbitrarily high maximum total capacity and then include the value of growth options in aggregate firm value as long as the marginal option contributes at least 0.05% to the option value component of the firm.

[7] The simulation model was programmed in Fortran 77 running on a Transtec i860-based parallel processor computer.

the book value on the last day of each year. In our simple view of the firm, book value is the historic cost of the assets-in-place. No accumulated depreciation is taken into account because of the assumption that productive assets last forever. Earnings for the year is calculated by cumulating operating cash flow over 250 days in a "cash account" where cash surpluses attract interest at the risk free rate.[8] Again, no depreciation is charged in calculating earnings because of the assumption that productive assets are infinite-lived. Aggregate accumulated earnings are assumed to be fully distributed at the year-end. Similarly new equity-financed capital investment is cumulated to a year-end value by compounding forward the investment cash flows on a daily basis at the risk-free rate.

Annual equity returns for year t, $R(t)$, are calculated assuming that earnings are fully distributed, i.e.

$$R(t) = \frac{MV(t) + \pi(t) - I(t)}{MV(t-1)} - 1 \qquad (14)$$

where $I(t)$ is new equity-financed investment compounded forward to the year-end. In the absence of bankruptcy costs and taxes and with perfect and complete markets, the firm's dividend policy is irrelevant to valuation (Miller and Modigliani, 1961).

To implement the simulation, we assume that the time 0 starting value for θ in each firm-history is drawn from a uniform distribution between 2.0 and 15.0; $r_m = 11.0\%$ per annum and $r = 3.5\%$ per annum (i.e. the market risk premium is assumed to be 7.5% per annum); $\sigma_m^2 = .12$; $\alpha = 0$; $\gamma = 0$; $c_1 = 0$ and $c_2 = 0.5$; $k = 100$.[9] To ensure that the simulated data we analyze is "seasoned", we exclude the first two years of each firm history, other than as a source of data for explanatory variables. Further, we drop firms in any year that have not started trading and, hence, for which BE $= 0$ (i.e. firms which have made no investments in productive assets prior to or including that year).

[8] There is no distinction between earnings and operating cash flow in our model because there is no role for depreciation or other accounting accruals.

[9] At first sight, it seems that the selected values of γ, c_1, and c_2 imply that we are assuming a perfectly competitive product market. Note, however, that γ and c_2 only appear in valuation expressions within the smaller expression $(2\gamma + c_2)$ (see equations (9) and (11)). As a consequence, any feasible combination of γ and c_2 satisfying the condition $(2\gamma + c_2) = .5$. will be consistent with the output of the simulations. Thus, a perfectly competitive product market is consistent with this condition - but so are many other combinations of demand and cost function conditions.

3. Model Fundamentals, ME, BE/ME, E/ME and Returns

3.1. Underlying Asset Beta, Total Volatility and Returns

Table 1 shows how mean and median returns vary with the CAPM beta and total volatility, σ, of the underlying assets. The results clearly show that beta is positively associated returns, as predicted by equation (3). Perhaps more interestingly, the total volatility of the underlying assets has a negative relationship with median return, although no clear-cut relationship between volatility and mean return is observed. The general increase in skewness of returns, as indicated by the difference between mean and median returns, with volatility is a notable feature of the conditional returns distributions and is consistent with equity returns resembling returns from an options portfolio.

3.2. θ, Capacity Utilization and Returns

Equation (2) indicates that the expected return for a call option depends on underlying asset beta and on the option elasticity. The latter depends on the moneyness of the option. In our model, both production and investment options will be deeper out-of-the-money for lower values of the state variable, θ, *ceteris paribus*. Hence, we predict that returns will be negatively associated with θ. Further, the number of production and investment options owned by the firm depends on the number of installed units of capacity. The respective elasticities of production and investment options will reflect the level of θ and to the level of installed capacity. When θ is high relative to installed capacity, the firm will operate at, or close to, full capacity and option elasticities and returns will be relatively low, and vice versa. Thus, we predict that there will be a negative relation between expected returns and capacity utilization..

In Table 2 we examine the relation between returns and, respectively, the state variable θ (Panel A) and prior year capacity utilization (Panel B) for different CAPM beta groups. The focus is on how well θ and capacity utilization explain returns after controlling for CAPM beta, which Table 1 showed is an important determinant of mean and median returns. Panel A shows that mean returns are negatively related to θ. As predicted, lower values of θ are associated with higher returns. This is consistent with returns reflecting risk premia associated with investment and production options. The influence of θ is most pronounced and virtually monotonic when CAPM beta exceeds 0.1, and on average the returns on high θ portfolios exceed the returns on low θ portfolios by approximately one and a half times. As would be predicted from equation (2) if θ is correlated with average option elasticity, the θ effects are greatest for high CAPM beta values.

Panel B in Table 2 shows that capacity utilization is also strongly associated with mean returns. On average, returns for the lowest capacity utilization group are sixty-five percent greater than for the highest capacity utilization group. The variation of returns by capacity utilization group is almost monotonic for CAPM beta values above 0.2. Mean returns in the highest capacity utilization portfolios are more than twice the level for the lowest capacity utilization portfolios. As in the case of the θ portfolios in Panel A, there is little detectable variation in returns across capacity utilization for low CAPM beta portfolios, as would be expected when there is a multiplicative relationship between elasticity, beta and returns.

3.3. Fundamental Factors, ME, BE/ME and E/ME

Table 3 shows the univariate relations between ME, BE/ME, E/ME and the model fundamental factors: CAPM beta (Panel A), volatility (Panel B), θ (Panel C) and capacity utilization (Panel D). In all cases ME is positively skewed, as would be anticipated on the basis of real world data. The results in Panel A show that ME generally decreases with beta. This is consistent with theoretical priors (Berk, 1995). *Ceteris paribus*, firms with higher costs of capital are expected to invest less and to have lower embedded growth option value.[10] Overall, mean ME increases with respect to volatility, whereas the median ME shows no clear relationship with volatility. Thus, there is an increase in the skewness of market value as volatility increases. This outcome is intuitive. Firms with higher underlying volatility have a greater chance of becoming very large. Also consistent with expectations, mean and median ME also increase with respect to θ and capacity utilization. Thus, ME certainly appears to have the potential to serve as a proxy for all four fundamental model factors.

BE is constrained to be positive in the model, reflecting the fact that there is no debt or bankruptcy. If demand falls, market value can decline to very low levels relative to book value, which remains unchanged because of the irreversibility of investments in productive capacity.[11] This gives rise to positive skewness in

[10] It is interesting to note that the focus of attention in explaining the observed negative correlation between firm size and beta estimates has often been on the effects of size-related measurement errors in returns resulting from market microstructural effects (e.g. Dimson and Marsh 1986). These results suggest that causality could run from beta to firm size.

[11] High BE/ME in the simulations is partly attributable to the absence of abandonment options in the model. However, even if we incorporated abandonment options we would still expect to

BE/ME.[12] Table 3 shows that BE/ME is strongly, and almost monotonically, related to CAPM beta, total volatility, θ and capacity utilization. Median BE/ME is almost constant across volatility portfolios. Thus, the association between mean BE/ME and volatility reflects the increase in the skewness of BE/ME as volatility increases. As in the case of market value, the results in Table 3 indicate that BE/ME potentially serves as a proxy for all four fundamental model factors.

Table 3 also reveals that E/ME is clearly associated with CAPM beta. This is predicted by traditional valuation perspectives. However, existing valuation perspectives would not predict the negative relationship observed between E/ME and volatility. We believe that this is caused by the positive relationship between the option values embedded in market value and volatility. The positive association between E/ME and capacity utilization also reflects the non-linearity in the valuation function. Holding capacity constant, earnings fall faster than market value as product demand falls. However, the overall insensitivity of E/ME to θ reflects the fact that both market value and earnings respond quickly to changes in underlying demand.

Overall, these results strongly suggest that ME, BE/ME and E/ME are related to some or all of CAPM beta, volatility, θ and capacity utilization.. The distribution of equity returns is also related to the same fundamental variables. In practice the lack of observability of the fundamental model factors appears to create a natural role for ME, BE/ME and E/ME as information proxies for the fundamental determinants of returns. In the next section we show how portfolio selection strategies, based on ME, BE/ME and E/ME, effectively sort firms by the fundamental factors.

3.4. Portfolio Strategies and Underlying Fundamentals

In Table 4 we illustrate how effectively portfolio selection strategies based upon ME, BE/ME and E/ME partition firms by the fundamental economic determinants of returns: CAPM beta, total volatility, the value of the state variable and capacity utilization. Portfolios are formed based upon the ranking of firms

observe high values if the abandonment value is sufficiently low. Firms with very high book-to-market values have very low growth option value and relatively low value attached to assets in place. Generally such firms will have significant excess operating capacity because they will have exercised options to shut down capacity.

[12] Note that, in the real world, conservative accounting practices will result in the effective truncation of BE/ME at the top end of its distribution because of assets being written off to their recoverable amount.

into deciles at the beginning of each year by ME, BE/ME and E/ME. For each decile portfolio, the mean underlying asset beta, total volatility, state variable and capacity utilization for the whole period of the simulation are calculated.

The results in Table 4 suggests that forming portfolios by either ME, BE/ME or E/ME achieves a monotonic ordering of firms by underlying asset beta. For ME, the association with beta is negative, and for BE/ME and E/ME, the association is positive. With respect to underlying asset volatility, the sorting produces a small, negative monotonic relationship between E/ME portfolio rankings and volatility. The relationship between portfolios based on ME and BE/ME rankings and volatility is mildly U-shaped, reflecting the skewness induced in both ME and BE/ME by changes in volatility indicated in Table 2. In contrast, no beta- and volatility-related skewness effects are observed for E/ME and, as a consequence, E/ME appears to sort firms on both dimensions.

Portfolios formed by ME (BE/ME) achieves a positive (negative) sorting by the state variable, θ. In contrast, sorting by E/ME does not discriminate to any great extent on the basis of θ. Similarly, sorting by ME does not discriminate firms by capacity utilization, whereas sorting by BE/ME and E/ME clearly also effectively ranks firms by capacity utilization. Notably, the ability of BE/ME to discriminate by capacity utilization is very high.

3.5. Summary

Overall, the results in Tables 1 to 4 suggest that returns and instruments such as ME, BE/ME and E/ME reflect the underlying economic fundamentals thought important to valuing firms as portfolios of real options. All variables reflect some or all of CAPM beta, volatility, the level of demand, as represented by the state variable, and the level of capacity utilization. Given that expected returns also depend on these fundamentals, there appear to be a good reasons for believing that the role of these instruments in explaining empirical stock returns is based on rational economic grounds and, in particular, to their role as information proxies for economic fundamentals.

4. Returns and ME, BE/ME and E/ME

4.1. Univariate Results

We now investigate ability of each of ME, BE/ME and E/ME to explain the cross-section of returns. Initially, we do this by considering the properties of returns for portfolios sorted by beginning-period ME, BE/ME and E/ME respectively. The results are shown in Table 5. Here, whether the measure of central tendency is captured by the mean or the median return of firms entering into a given ranking portfolio, as ME increases, return decreases. In contrast, as BE/ME and E/ME increase so does return. These outcomes are consistent with prior empirical studies. They are also consistent with the links between model fundamentals and returns documented in Tables 1 and 2, and with associations between model fundamentals and ME, BE/ME and E/ME, as documented in Table 4. Clearly the links between model fundamentals and ME, BE/ME and E/ME are complex and non-linear. We observe in Table 5 the ability of each empirically observable instrument to capture information about underlying asset CAPM beta and option elasticity which, in turn, determine expected returns.[13]

4.2. Multivariate Results

We now turn to regressions of actual returns (as proxies for expected returns) on all combinations of the natural logarithm of ME, the natural logarithm of BE/ME and E/ME. We also add time dummies to the regressions. This enables us to see the ability of ME, BE/ME and E/ME to explain the cross-section of relative returns within years, controlling for systematic differences in *ex post* realized returns between years. Effectively this design helps control for the effects of within-year systematic movements in the state variable.

Table 6 provides the regression results. The univariate regression results are consistent with the univariate portfolio results in Table 5. ME, BE/ME and E/ME have, respectively, negative, positive and positive associations with expected returns. For completeness, we also include multivariate regressions. The multivariate results suggest reasonable consistency between our simulated world and the empirical results reported elsewhere (e.g., Fama and French 1992). One point of divergence between the simulation results and prior empirical results is the positive coefficient on ME when it appears in any regression with BE/ME. We attribute this to the high degree of correlation between ME and BE/ME in the simulated data ($\rho > .8$) compared with the empirical data ($\rho < .5$).[14] Fur-

[13]To give a further indication of the impact of capacity utilization on returns, we regressed actual returns on underlying asset CAPM beta and total risk, the state variable and capacity utilization, both at the beginning of the period. This regression suggests that capacity utilization has a small, negative relationship on returns, as asserted above. Results are available from the authors.

[14]The correlation on the empirical data is calculated from all non-financial NYSE and AMEX

ther, ME is not statistically significant at conventional levels when included with E/ME.

Finally, in Table 7 we examine the results of a two-way sort on ME and on BE/ME. Firms are assigned to portfolios within years based on beginning-year values of ME and BE/ME. Sorting takes place each year by ME first and then by BE/ME. In each cell we report the mean and median return for the relevant portfolio, aggregated across all years. The results suggest that mean and median returns are negatively associated with ME and positively associated with BE/ME. These results are consistent with the empirical results in Fama and French (1992).

5. Conclusions

The empirical research literature and investment management practice has uncovered a variety of factors that appear to explain and predict CAPM-beta adjusted returns, including the size effect, the book-to-market equity effect and the earnings yield effect. Opinion appears split on whether these empirical "anomalies" arise because of research design biases, market inefficiency or an, as yet, incomplete theoretical explanation of risk premia that the estimated CAPM beta fails to capture.

In this paper we argue that, when investment is irreversible, firms face option-like opportunities in their investment and production decisions. We develop a model in which stock prices accounts fully for the value of these real options. Importantly, the underlying assets of the firm are priced according to the CAPM. Based on a large simulation experiment we show, first, that the CAPM beta, total risk, level of the state variable and the degree of capacity utilization simultaneously influence the distributions of returns, size, book-to-market equity and the earnings-price ratio. Second, we show that portfolios based on the market value of equity, book-to-market equity and earnings yield sort by some or all of the underlying fundamental variables that affect the average expected return on a portfolio of options (including the CAPM beta and, in relation to the average option elasticity of the real options, the total risk of the underlying asset, the state variable and the degree of capacity utilization). Third, consistent with prior empirical research, simulated equity returns are associated with market value of equity, book-to-market equity and earnings yield. Our results are consistent with

stocks for which earnings, book value and fiscal year-end market value is available on *Compustat* over the period 1975-94. Returns data is obtained from the *CRSP* monthly returns file. The data set comprises 27,793 firm-years.

the Fama and French factors being correlated with the CAPM betas of underlying assets and with the elasticities of option-like components of firm value.

The paper also suggests additional lines of inquiry for future research. For example, our approach essentially suggests that size, book-to-market equity and the earnings-price ratio are useful information sources about the determinants of expected returns. It does not explain why certain instruments appear to be superior predictors of returns than others in real world data. For example, if the argument of this paper is accepted, it seems reasonable to assume that the market model beta would be another source of information about, in particular, the CAPM beta of the underlying asset. Why, in empirical data, it appears to be dominated by other variables is an open question. This is one area for future research[15]

Additionally, viewing the firm as a portfolio of options raises issues concerning the shape of the distribution of returns. Our analysis suggests that portfolios formed on a number of different bases exhibit skewness in the distribution of returns. The distributional properties of returns on portfolios selected on the basis factors such as ME, BE/ME and E/ME could be informative in establishing whether real option-related risk premia are being captured by these instruments in practice.

[15] In the simulations, the market model beta is quite capable of capturing information about the CAPM beta of the underlying asset. Naturally, we do not suffer from some of the problems of beta estimation that exist in real world data. In particular, there is no difficulty in measuring the single factor determining returns.

References

Ball, R., S.P. Kothari and J. Shanken, 1995, Problems in measuring portfolio performance: An application to contrarian investment strategies, *Journal of Financial Economics* 38, 70-107.

Banz, R.W., 1981, The relationship between return and market value of common stocks, *Journal of Financial Economics* 9, 3-18.

Basu, S., 1983, The relationship between earnings yield, market value, and return for NYSE common stocks: Further evidence, *Journal of Financial Economics* 12, 129-156.

Berk, J.B., 1995, A critique of size-related anomalies, *Review of Financial Studies* 8, 275-286.

Berk, J.B., R.C. Green and V. Naik, 1998, Optimal investment, growth options and security returns, *Journal of Finance,* forthcoming.

Black, F., 1972, Capital market equilibrium with restricted borrowing, *Journal of Business* 45, 444-455.

Breen, W.J. and R.A. Korajczyk, 1993, On selection biases in book-to-market based tests of asset pricing models, Working paper no. 167, Northwestern University.

Brown, S.J., W. Goetzmann and S.A. Ross, 1995, Survival, *Journal of Finance* 50, 553-580.

Cox, J.C. and M. Rubinstein, 1985, *Options Markets*, Englewood Cliffs: Prentice-Hall.

Dimson, E. and P. Marsh, 1986, Event study methodologies and the size effect, *Journal of Financial Economics* 17, 113-142.

Dixit, A.K., and R.S. Pindyck, 1994, *Investment Under Uncertainty*, Princeton University Press.

Dichev, I., 1998, Is the risk of bankruptcy a systematic risk?, *Journal of Finance 53, 1131-1148.*

Fama, E.F. and K.R. French, 1992, The cross-section of expected returns, *Journal of Finance* 47, 427-465.

Fama, E.F. and K.R. French, 1995, Size and book-to-market factors in earnings and returns, *Journal of Finance* 50, 131-155.

Fama, E.F. and K.R. French, 1996a, Multifactor explanations of asset pricing anomalies, *Journal of Finance* 51, 55-84.

Fama, E.F. and K.R. French, 1996b, The CAPM is wanted, dead or alive, *Journal of Finance* 51, 1947-1958.

Jagannathan, R. and Z. Wang, 1996, The conditional CAPM and the cross-section of expected returns, *Journal of Finance* 51, 65-91.

Kothari, S.P., J. Shanken and R.G. Sloan, 1995, Another look at the cross-section of expected stock returns, *Journal of Finance* 50, 185-224.

Lakonishok, J., A. Shleifer and R.W. Vishny, 1994, Contrarian investment, extrapolation, and risk, *Journal of Finance* 49, 1541-1578.

Lintner, J., 1965, The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets, *Review of Economics and Statistics* 47, 13-37.

Miller, M. and F. Modigliani, 1961, Dividend policy, growth and the valuation of shares, *Journal of Business* (October), 411-433.

Pindyck, R.S., 1988, Irreversible investment, capacity choice, and the value of the firm, *American Economic Review* 78, 969-985.

Rosenberg, B., K. Reid and R. Lanstein, 1985, Persuasive evidence of inefficiency, *Journal of Portfolio Management* 11, 9-17.

Sharpe, W.F., 1964, Capital asset prices: A theory of market equilibrium under conditions of risk, *Journal of Finance* 19, 425-442.

Table 1
Mean and Median Returns Analyzed by CAPM Beta (β) and Total Volatility of the Underlying Asset (σ)

	$\sigma = .15$	$\sigma = .16$	$\sigma = .17$	$\sigma = .18$	$\sigma = .19$	$\sigma = .20$	$\sigma = .21$	$\sigma = .22$	*All*
$\beta = 0$	.043	.035	.040	.030	.042	.035	.042	.036	.038
	-.000	*-.012*	*-.006*	*-.011*	*-.016*	*-.026*	*-.007*	*-.024*	*-.012*
$\beta = .1$	.048	.043	.046	.055	.048	.040	.045	.066	.049
	.004	*.003*	*-.001*	*.002*	*-.008*	*-.028*	*-.016*	*.006*	*-.005*
$\beta = .2$	.064	.074	.073	.073	.071	.058	.062	.050	.066
	.026	*.027*	*.022*	*.013*	*.002*	*-.005*	*-.009*	*-.022*	*.009*
$\beta = .3$	.076	.080	.087	.087	.087	.090	.090	.090	.086
	.039	*.018*	*.033*	*.032*	*.013*	*.016*	*.016*	*.007*	*.023*
$\beta = .4$	.104	.097	.105	.098	.086	.110	.086	.088	.097
	.060	*.047*	*.054*	*.035*	*.010*	*.040*	*-.002*	*-.012*	*.032*
$\beta = .5$	.119	.126	.108	.122	.116	.129	.117	.107	.118
	.082	*.075*	*.065*	*.055*	*.055*	*.048*	*.038*	*.025*	*.057*
$\beta = .6$	.124	.127	.123	.127	.138	.128	.134	.137	.130
	.085	*.080*	*.069*	*.073*	*.069*	*.046*	*.064*	*.051*	*.068*
$\beta = .7$	.145	.144	.158	.141	.145	.149	.150	.137	.146
	.090	*.098*	*.112*	*.075*	*.070*	*.066*	*.060*	*.036*	*.079*
$\beta = .8$	.160	.161	.154	.153	.166	.161	.150	.134	.155
	.106	*.106*	*.091*	*.085*	*.094*	*.080*	*.056*	*.042*	*.084*
$\beta = .9$	.168	.167	.165	.179	.173	.184	.179	.172	.173
	.124	*.118*	*.105*	*.100*	*.105*	*.110*	*.088*	*.068*	*.104*
$\beta = 1.0$	.187	.182	.189	.194	.192	.193	.194	.186	.190
	.136	*.125*	*.126*	*.131*	*.120*	*.114*	*.103*	*.081*	*.120*
$\beta = 1.1$	.199	.205	.208	.203	.199	.192	.209	.218	.204
	.141	*.136*	*.140*	*.137*	*.134*	*.110*	*.121*	*.103*	*.130*
$\beta = 1.2$	.215	.215	.218	.219	.210	.223	.225	.213	.217
	.160	*.152*	*.145*	*.150*	*.130*	*.132*	*.131*	*.108*	*.142*
All	.130	.127	.129	.129	.129	.130	.129	.126	.128
	.085	*.080*	*.076*	*.069*	*.062*	*.054*	*.050*	*.035*	*.065*

Note: The first line in each cell contains the mean value, the second line contains the median value in italics.

Table 2: Mean and Median Equity Returns Analyzed by the CAPM beta (β), Level of the State Variable (θ) and Capacity Utilization (*Capacity*)

Panel A:	θ Portfolio				
	Low	*2*	*3*	*4*	*High*
Min θ	.06	4.38	7.79	11.93	18.19
Max θ	4.37	7.78	11.92	18.18	84.67
$\beta = 0$	.022	.040	.053	.038	.036
	-.031	*-.011*	*-.001*	*-.014*	*-.012*
$\beta = .1$	.041	.056	.054	.047	.050
	-.024	*-.004*	*0.005*	*-.009*	*.003*
$\beta = .2$	.076	.071	.072	.068	.057
	.009	*.018*	*.012*	*.012*	*.001*
$\beta = .3$	.098	.089	.091	.075	.083
	.026	*.025*	*.017*	*.006*	*.023*
$\beta = .4$	.103	.087	.100	.088	.097
	.031	*.014*	*.031*	*.030*	*.031*
$\beta = .5$	.133	.119	.127	.104	.116
	.068	*.050*	*.063*	*.034*	*.053*
$\beta = .6$	.168	.130	.135	.124	.122
	.101	*.052*	*.079*	*.055*	*.067*
$\beta = .7$	.188	.166	.162	.135	.150
	.101	*.083*	*.080*	*.072*	*.083*
$\beta = .8$	.214	.186	.154	.153	.141
	.122	*.099*	*.074*	*.079*	*.075*
$\beta = .9$	.244	.222	.196	.167	.161
	.146	*.142*	*.121*	*.088*	*.093*
$\beta = 1.0$	.284	.240	.199	.182	.180
	.181	*.144*	*.111*	*.108*	*.107*
$\beta = 1.1$	.294	.270	.246	.197	.191
	.197	*.162*	*.143*	*.117*	*.115*
$\beta = 1.2$	.370	.301	.252	.228	.179
	.255	*.180*	*.156*	*.115*	*.116*
All	.153	.148	.138	.119	.109
	.072	*.068*	*.065*	*.049*	*.049*

Table 2 (continued)

Panel B:	Capacity Portfolio				
	Low	*2*	*3*	*4*	*High*
Min Capacity (%)	0.00	31.95	42.86	65.93	96.70
Max Capacity (%)	31.94	42.85	65.92	96.69	100.00
$\beta = 0$	.026	.055	.045	.036	.034
	-.022	*-.006*	*-.012*	*-.011*	*-.016*
$\beta = .1$	.054	.056	.057	.046	.045
	.004	*.002*	*-.007*	*-.011*	*-.002*
$\beta = .2$	.077	.081	.065	.073	.058
	.009	*-.005*	*.007*	*.017*	*.006*
$\beta = .3$	.130	.098	.090	.079	.081
	.052	*.014*	*.031*	*.017*	*.020*
$\beta = .4$	.128	.091	.093	.096	.094
	.056	*.024*	*.026*	*.025*	*.034*
$\beta = .5$	.169	.141	.133	.104	.111
	.101	*.052*	*.059*	*.045*	*.057*
$\beta = .6$	.202	.146	.157	.115	.119
	.125	*.069*	*.088*	*.053*	*.064*
$\beta = .7$	.224	.209	.170	.152	.124
	.156	*.101*	*.087*	*.077*	*.071*
$\beta = .8$	.248	.224	.187	.145	.132
	.144	*.126*	*.098*	*.077*	*.078*
$\beta = .9$	.331	.238	.240	.157	.142
	.220	*.140*	*.148*	*.091*	*.093*
$\beta = 1.0$	.361	.317	.254	.178	.157
	.229	*.203*	*.154*	*.100*	*.107*
$\beta = 1.1$	.436	.311	.302	.197	.161
	.314	*.223*	*.193*	*.116*	*.113*
$\beta = 1.2$	.425	.398	.337	.210	.168
	.288	*.274*	*.220*	*.115*	*.129*
All	.192	.173	.157	.115	.115
	.102	*.081*	*.075*	*.049*	*.066*

Note: θ is the state variable (demand) at the beginning of the year, β is the CAPM beta of the underlying asset, *Capacity* is the average level of capacity utilization over the previous year. Portfolio assignments for θ are based on the quintiles of the distribution of θ. Due to the highly skewed nature of the distribution of capacity utilization, observations are assigned to portfolios based on *Capacity* utilization using cut-off levels of capacity defined by as the fifth, tenth, twenty-fifth and fiftieth percentiles of the capacity utilization distribution. The first line in each cell contains the mean return and the second line (in italics) contains the median return.

Table 3: Mean and Median Equity (ME), Book-to-Market Equity (BE/ME) and Earnings-Price Ratio (E/ME) Analyzed by CAPM Beta (β), Total Volatility of the Underlying Asset (σ), Level of the State Variable (θ) at the Beginning of the Year and Capacity Utilization (*Capacity*) in the Prior Year

Panel A:	ME	BE/ME	E/ME
$\beta = 0$	1532.4	.185	.016
	587.9	*.071*	*.015*
$\beta = .1$	1005.1	.368	.026
	311.7	*.122*	*.025*
$\beta = .2$	722.2	.489	.038
	259.8	*.163*	*.038*
$\beta = .3$	639.8	.646	.053
	178.6	*.226*	*.052*
$\beta = .4$	433.3	1.017	.067
	117.7	*.303*	*.066*
$\beta = .5$	356.9	1.094	.082
	98.1	*.364*	*.081*
$\beta = .6$	284.2	1.152	.098
	86.5	*.425*	*.096*
$\beta = .7$	220.1	1.823	.113
	73.2	*.473*	*.111*
$\beta = .8$	181.6	1.574	.129
	64.4	*.551*	*.126*
$\beta = .9$	162.5	1.438	.143
	59.3	*.600*	*.140*
$\beta = 1.0$	136.5	1.429	.157
	52.6	*.633*	*.155*
$\beta = 1.1$	137.2	1.582	.173
	48.9	*.684*	*.170*
$\beta = 1.2$	107.1	1.504	.187
	46.2	*.738*	*.184*
All	455.8	1.100	.098
	100.8	*.369*	*.093*

Table 3 (continued)

Panel B: Volatility	ME	BE/ME	E/ME
$\sigma = .15$	332.4	.658	.106
	102.5	*.357*	*.103*
$\sigma = .16$	393.6	.726	.104
	99.3	*.370*	*.101*
$\sigma = .17$	390.6	.836	.102
	97.1	*.369*	*.097*
$\sigma = .18$	426.2	.938	.099
	93.6	*.375*	*.095*
$\sigma = .19$	476.0	1.087	.097
	101.4	*.373*	*.091*
$\sigma = .20$	445.0	1.200	.095
	105.2	*.369*	*.088*
$\sigma = .21$	561.2	1.435	.093
	108.3	*.369*	*.085*
$\sigma = .22$	621.6	1.915	.090
	99.8	*.375*	*.082*
All	455.8	1.100	.098
	100.8	*.369*	*.093*

Table 3 (continued)

Panel C: State Variable θ	*ME*	*BE/ME*	*E/ME*
Low	16.1	4.765	.092
	8.0	*2.421*	*.082*
2	64.8	1.229	.100
	35.5	*0.984*	*.092*
3	160.4	.623	.099
	91.2	*.521*	*.088*
4	360.2	.340	.097
	214.7	*.293*	*.088*
High	1,406.2	.159	.088
	784.5	*.125*	*.075*
All	401.6	1.422	.095
	105.0	*.461*	*.085*

Panel D: Capacity			
Low	44.5	7.185	.085
	15.6	*3.401*	*.076*
2	99.5	2.315	.092
	37.7	*1.477*	*.084*
3	211.4	1.286	.096
	70.4	*.758*	*.087*
4	485.0	0.620	.096
	158.7	*.327*	*.087*
High	443.2	.436	.102
	127.6	*.250*	*.100*
All	401.6	1.422	.095
	105.0	*.461*	*.086*

Note: θ is the state variable (demand) at the beginning of the year, β is the CAPM beta of the underlying asset, *Capacity* is the average level of capacity utilization over the previous year. Portfolio assignments for θ are based on the quintiles of the distribution of θ. Due to the highly skewed nature of the distribution of capacity utilization, observations are assigned to portfolios based on *Capacity* utilization using cut-off levels of capacity defined by as the fifth, tenth, twenty-fifth and fiftieth percentiles of the capacity utilization distribution. The first line in each cell contains the mean return and the second line (in italics) contains the median return.

Table 4: Mean Values of Fundamental Characteristics and Return for Portfolios Ranked By Market Value of Equity (ME), Book-to-Market (BE/ME) and Earnings-Price (E/ME).

Panel A: ME

	β	σ	θ	*Capacity*
Decile				
Low	0.771	0.187	2.312	0.831
2	0.724	0.185	4.258	0.784
3	0.702	0.185	6.096	0.770
4	0.703	0.184	8.055	0.772
5	0.681	0.183	10.055	0.784
6	0.652	0.184	12.254	0.802
7	0.605	0.184	14.752	0.821
8	0.525	0.184	17.599	0.844
9	0.396	0.186	21.353	0.866
High	0.234	0.189	34.901	0.910

Panel B: BE/ME

	β	σ	θ	*Capacity*
Decile				
Low	0.140	0.189	29.952	0.932
2	0.301	0.186	19.878	0.890
3	0.445	0.184	17.179	0.874
4	0.568	0.183	15.170	0.861
5	0.653	0.183	13.149	0.842
6	0.716	0.182	11.160	0.821
7	0.763	0.182	9.260	0.800
8	0.786	0.183	7.277	0.778
9	0.809	0.185	5.385	0.740
High	0.811	0.192	3.222	0.643

Panel C: E/ME

	β	σ	θ	$Capacity$
Decile				
Low	0.035	0.191	11.033	0.762
2	0.153	0.186	15.145	0.801
3	0.289	0.186	14.939	0.811
4	0.421	0.185	14.180	0.814
5	0.551	0.185	13.497	0.823
6	0.684	0.185	12.971	0.827
7	0.809	0.185	12.647	0.832
8	0.923	0.184	12.375	0.838
9	1.021	0.182	12.460	0.841
High	1.108	0.181	12.381	0.833

Note: ME is the market value of equity at time t, BE is the book value of equity at t, E is earnings at t, θ is the state variable (demand) at the beginning of the year, β is the CAPM beta of the underlying asset, σ is the residual volatility of underlying asset cash flows and $Capacity$ is the average level of capacity utilization over the previous year.

Table 5: Mean and Median Annual Returns for Portfolios Based Upon Rankings at the Beginning of the Year by Market Value (ME), Book-to-Market Equity (BE/ME) and Earnings-Price Ratio (E/ME)

Portfolio	ME	BE/ME	E/ME
1	.144	.055	.042
	.080	*.001*	*-.013*
2	.148	.087	.058
	.085	*.026*	*-.001*
3	.145	.104	.086
	.080	*.043*	*.024*
4	.147	.123	.098
	.082	*.062*	*.035*
5	.140	.138	.126
	.076	*.072*	*.059*
6	.141	.148	.140
	.075	*.086*	*.075*
7	.131	.149	.159
	.067	*.088*	*.090*
8	.116	.158	.175
	.055	*.093*	*.110*
9	.100	.158	.191
	.040	*.090*	*.123*
10	.069	.161	.207
	.011	*.089*	*.138*

Note: The first line in each cell contains the mean value, the second line contains the median value in italics.

Table 6: OLS Regression Relationships between Annual Returns and Market Value (ME), Book-to-Market Equity (BE/ME) and Earnings-Price Ratio (E/ME)

$LogME$	$LogBE/ME$	E/ME	$\bar{R}^2$
-0.009			.114
(23.88)			
	0.026		.119
	(42.00)		
		0.820	.131
		(68.73)	
0.022	0.057		.122
(26.90)	(43.79)		
	0.005	0.770	.131
	(6.53)	(54.59)	
-0.001		0.815	.131
(1.22)		(64.38)	
.008	.018	0.724	.131
(9.39)	(11.36)	(48.36)	

Note: Regressions are of the form:

$$RET_{jt} = \sum \delta_t + \gamma.E + \nu_{jt}$$

where RET_{jt} is the return on stock j in period t, δ_t are time period specific intercept dummy variables and E represents a set of explanatory variables including $\log ME_{j,t-1}$, where $ME_{j,t-1}$ is the market value of equity at time $t-1$ for firm j, $\log(BE_{j,t-1}/ME_{j,t-1})$, where $BE_{j,t-1}$ is the book value of equity at $t-1$ for firm j, and $E_{j,t-1}/ME_{j,t-1}$, where $E_{j,t-1}$ are earnings for period $t-1$ for firm j. The figures in parentheses are t-statistics. $\overline{R}^2$ is the adjusted coefficient of determination. In the interests of parsimony, the coefficients on the time-specific intercept dummies are not reported. The data is trimmed by removing the extreme bottom and top 1% of observations. The main inferences drawn are insensitive to the inclusion or exclusion of outliers, although the point coefficient estimates are affected.

Table 7: Mean and Median Equity Returns for Simulated Market Data Analyzed by Market Value of Equity (ME) and Book-to-Market Equity (BE/ME)

		ME					
		Large	*2*	*3*	*4*	*Small*	*All*
	Low	.042	.075	.087	.097	.113	.070
		-.004	*.016*	*.026*	*.038*	*.057*	*.013*
	2	.059	.104	.135	.137	.140	.114
		.002	*.043*	*.070*	*.078*	*.083*	*.054*
	3	.079	.131	.153	.157	.160	.143
BE/ME		*.016*	*.071*	*.092*	*.093*	*.095*	*.079*
	4	.106	.148	.166	.172	.156	.153
		.044	*.085*	*.097*	*.105*	*.091*	*.090*
	High	.134	.162	.163	.165	.161	.159
		.069	*.093*	*.097*	*.090*	*.084*	*.089*
	All	.084	.124	.141	.146	.146	.128
		.025	*.061*	*.076*	*.081*	*.083*	*.065*

Note: The first line in each cell contains the mean portfolio return, the second line contains the median portfolio return (in italics). ME is the market value of equity and BE is the book value of equity at the beginning of the year for which the return is calculated.

Figure 1: The Model of the Firm

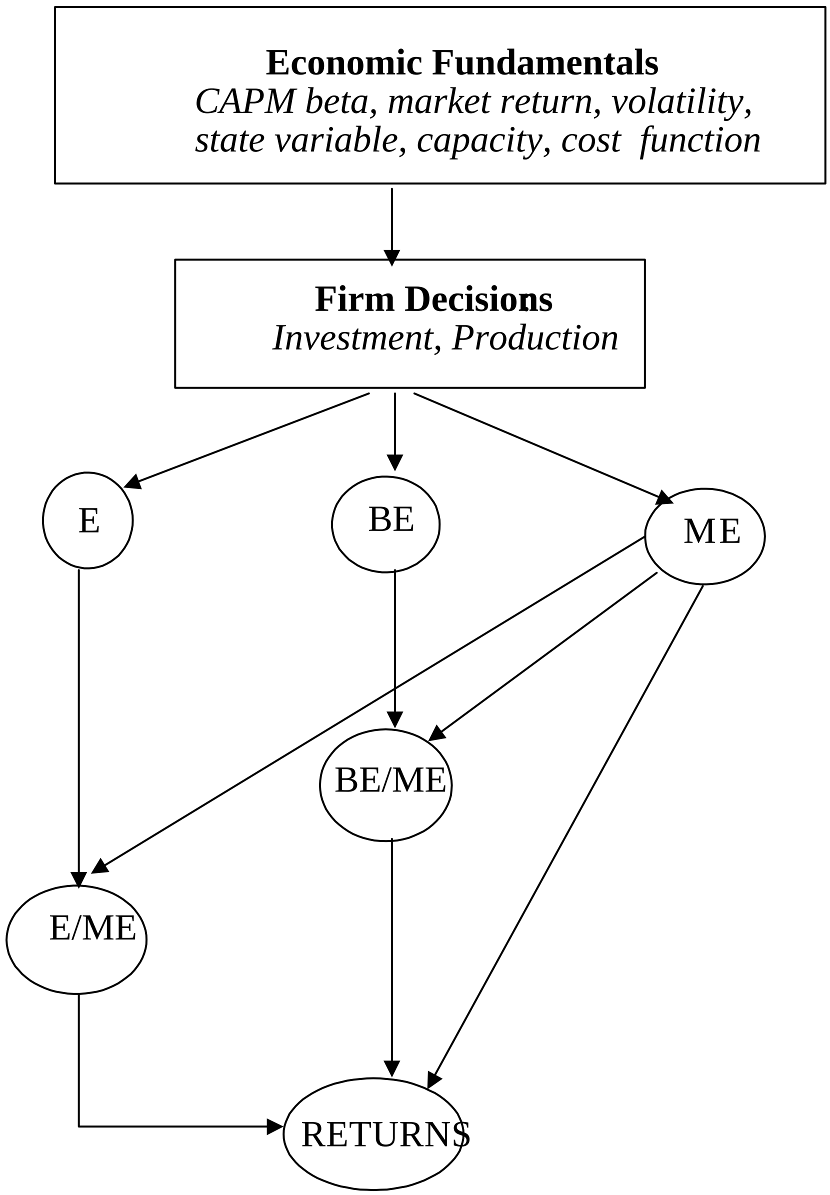

Figure 5.1: