Investment Options, Assets in Place, and the Risk of Stocks

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■ The market value of the firm is comprised of the value of assets in place and the present value of growth opportunities. The present value of growth opportunities reflects the value of future investments which are expected to yield rates of return in excess of the opportunity cost of capital. Growth opportunities exist when the competitive process that drives the rates of return on capital investment projects toward the firm's cost of capital is halted or delayed. Generally, the firm can delay the competitive process when there exist barriers to entry arising from economies of scale, product differentiation, brand loyalty, or patents. Since the firm is not obliged to undertake all of its future investment opportunities, the value of growth opportunities is best regarded as the present value of the firm's options to make future investments (see Myers [53]).

Empirical results suggest that a significant portion of the market value of equity is accounted for by growth opportunities. For instance, Kester [36, 37] estimates, by comparing the capitalized value of the firm's current earnings stream and the market value of the firm's equity, that the value of growth opportunities is half or more of the market value of equity for many firms. Furthermore, he finds that the fraction is about 70 to 80% in industries with high demand volatility. More recently, Pindyck [59] argues that the fraction of market value attributable to the value of capital in place should be only one-half or less for firms with reasonable demand volatility.[1]

The purpose of this paper is to examine the effect of the firm's growth opportunities on its systematic risk. Hamada [33], Rubinstein [61], Hill and Stone [34], and Chance [20] examine the impact of financial leverage on the systematic risk of the firm's common stocks. Lev [40] examines the relation between the systematic risk

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[1]Specifically, Pindyck [59] argues that if demand volatility is 0.2 or more, more than half of the firm's value is accounted for by its growth opportunities (see p. 979).

and asset characteristics. Mandelker and Rhee [44] and Chen, Cheng, and Hite [21] investigate the joint impact of the degrees of operating and financial leverage on beta. In addition, Rubinstein [61], Myers [52], Myers and Turnbull [55], Brenner and Smidt [17], and Conine [23, 24] show that cyclicality is also an important determinant of beta. However, these studies make no distinction between the risk of assets already in place and the risk arising from the firm's growth opportunities. The primary focus of these studies has been the investigation into the relationship between the firm's systematic risk and characteristics of the firm's assets in place which are implicitly embodied in the firm's asset and financial structures.[2]

Other studies (see, e.g., Beaver, Kettler, and Scholes [2], Pettit and Westerfield [57], White [67], Breen and Lerner [11], Rosenberg and McKibben [60], Thompson [65], and Eskew [27]) examine the cross-sectional association between growth and beta. However, these studies have not drawn a clear distinction between growth as expansion and growth as profitable future investment options. Their measurement of the growth variable suggests that the term is used according to the first interpretation, i.e., growth as the rate of expansion of the firm's assets, sales, or earnings. It is important to note that a firm is not a growth firm merely because its assets and earnings are growing over time. To become a growth firm, the firm should be able to earn returns on its investments which are larger than its cost of capital. That is, the essence of growth is not the expansion but the existence of profitable investment opportunities.[3]

This paper employs contingent claims analysis to decompose the firm's systematic risk into the risk associated with its assets in place and the risk arising from future growth opportunities.[4,5] Contingent claims analysis is well-suited to such decomposition, since a growth opportunity can be regarded as a call option on a real asset where the option's exercise price is the future investment needed to acquire the asset. Whether the option has any value at expiration depends on the asset's future value. In essence, this study predicts that the greater the portion of a stock's market value accounted for by the firm's growth opportunities, the higher the stock risk. Overall, our empirical results strongly support this hypothesis. The remainder of the paper is organized as follows. Section I presents the model. Section II describes data and the variable estimation procedure. Section III discusses our empirical findings, and Section IV concludes with a brief summary.

I. Assets in Place, Growth Options, and the Systematic Risk

A. The Contingent Claims Valuation of Growth Opportunities

Let VE be the current equilibrium market value of the firm's *equity*. Then, VE can be expressed as the sum of two parts:

$$VE = VEA + PVGO\,; \tag{1}$$

where VEA is the portion of the market value of the firm's equity which is accounted for by assets already in place, i.e., the present value of cash flows to shareholders generated from existing assets, and $PVGO$ is the present value of cash flows to shareholders from the firm's future investments. The existence of valuable investment options (i.e., $PVGO > 0$) presumes some imperfections (e.g., adjustment costs and market power) in the real sector. In light of the finding of Kester [36, 37] and Pindyck [59] that the fraction of equity value attributable to future growth options is nontrivial for

[2]For an excellent summary of the previous inquiries (theoretical and empirical) into the effects of operating risk, financial risk, risky debt, and market power on systematic risk, see Callahan and Mohr [19].

[3]A firm can increase its assets and earnings over time without an increase in stock price if the internal rate of return on its projects is the same as the firm's cost of capital (i.e., if projects' net present value is zero). See Miller and Modigliani [50] for this point.

[4]This study should be viewed in the spirit of recent strands of research which employ the contingent claims analysis for the evaluation of various real asset investment decisions (see, e.g., Tourinho [66], Pindyck [58], Brennan and Schwartz [13, 14], Brock, Rothschild, and Stiglitz [18], Paddock, Siegel, and Smith [56], Baldwin, Mason, and Ruback [1], Myers and Majd [54], Brennan and Schwartz [15, 16], Kester [36], McDonald and Siegel [47, 48], Majd and Pindyck [43], Pindyck [59], Mørck, Schwartz, and Stangeland [51], and Chung [22]). See Brennan [12] and Mason and Merton [45] for the general discussion of potential applicability of the option pricing model to the broad class of real assets investment decisions.

[5]Bowman [9] argues that there is no theoretical relationship between the systematic risk of stocks and growth opportunities. Bowman's study is seriously flawed, however, since he erroneously defines market beta in terms of accounting income. As will be shown in this paper, Bowman's definition of beta corresponds to the asset beta of this paper. More recently, Gahlon and Gentry [30] and Miles [49] define the systematic risk as a weighted average of the systematic risk associated with cash flows generated by assets already in place and that associated with the growth options. However, these studies do not provide empirical support for their theoretical results.

many firms, this paper takes the existence of growth opportunities as given.

Suppose that at time t the firm invests an amount I_t that will create an asset of value $x(t)$. Here, $x(t)$ can usefully be interpreted as the present (as of time t) value of net cash flows generated from the asset purchased at time t at cost I_t.[6] We assume that stochastic changes in $x(t)$ are spanned by existing assets, that is, there is an asset or a dynamic portfolio of assets whose price is perfectly correlated with $x(t)$.[7] With the spanning assumption, the value of growth opportunities can be obtained using the contingent claims analysis, which avoids assumptions regarding risk preferences or discount rates. We assume that $x(t)$ changes in the time interval $(t, t + dt)$ by:

$$dx(t) = x(t)[(\mu + \delta)\, dt + \sigma dw]\,; \qquad (2)$$

where μ is the instantaneous equilibrium rate of return on a security or dynamic portfolio of assets whose price is perfectly correlated with $x(t)$, $\mu + \delta$ is the instantaneous expected growth rate of $x(t)$, σ is the instantaneous standard deviation of the growth rate of $x(t)$, and dw is a Wiener process. The growth rate of $x(t)$ will typically be less than the rate of return (i.e., μ) on financial asset with comparable risk, since the growth rate of $x(t)$ will equal the rate of return on the comparable asset less cash flow that is earned on the project and paid out.[8] Hence δ is a negative constant.

Earlier, Miles [49] also employed contingent claims analysis to examine the implication of the options interpretation of growth opportunities for the risk of the firm's stock. The approach taken in this paper is somewhat more general than that of Miles since the latter implicitly makes the assumption that the growth rate $(dx(t)/x(t))$ of the asset value is identical to the rate of return (μ) on financial asset with comparable risk (i.e., $\delta = 0$). It is important to note however that, although the assumption of "zero δ" is justifiable for financial assets, the same assumption is not warranted for real assets. Although equilibrium in the capital market requires $\delta = 0$ for a non-dividend-paying stock since the expected rate of return on the stock must equal the opportunity cost of holding it,[9] the same line of reasoning does not apply to real assets. This is because nothing in the determination of equilibrium in the market for real assets requires that the expected rate of change in the value of an asset bear any particular relation to the opportunity cost of holding it (which is here μ).[10] This study explicitly incorporates this important facet of real asset valuation into the modeling process and thereby avoids the theoretical flaw in Miles [49]. In addition, our model is strictly in continuous time whereas Miles mixes the discrete-time capital asset pricing model (CAPM) with the continuous-time option pricing model.

The investment option available at time t is equivalent to a European call option with an exercise price, I_t, and terminal cash flow of $max[0, x(t) - I_t]$. Then, using the solution technique in Cox and Ross [26] and Smith [62],[11] it can be shown that the present value of the growth opportunity available at time t, $VG(t,0)$, is expressed as:[12]

$$VG(t, 0) = x(0)e^{\delta t}N(d_{1t}) - I_t\, e^{-rt}N(d_{2t})\,; \qquad (3)$$

where

$$d_{1t} = [\ln\{x(0)/I_t\} + (r + \delta)t]/\sigma\sqrt{t} + (1/2)\,\sigma\sqrt{t}$$
$$d_{2t} = [\ln\{x(0)/I_t\} + (r + \delta)t]/\sigma\sqrt{t} - (1/2)\,\sigma\sqrt{t}$$

$N(\,)$ = the cumulative normal distribution function, and
r = the instantaneous risk-free rate.

The present value of the firm's growth opportunities ($PVGO$) is then defined as the intertemporal summation of $VG(t,0)$:

$$PVGO = \sum_{t=1}^{\infty} VG(t, 0)\,. \qquad (4)$$

[6] The present study assumes that the future investment schedule is known at time zero. The framework presented in this paper, however, can easily be extended to the situation where both investment schedule and the future asset value (i.e., $x(t)$) are stochastic. It can be shown that the major results of the present study will still hold even if we allow the uncertainty in the firm's investment schedule, as long as the risk associated with future asset value is greater than or equal to *max*[risk of existing assets, risk of future investment schedule], which, we believe, is a reasonable characterization of the real world.

[7] This assumption implies that the firm can value its growth options independently of other assets and that there are securities in the market that can be combined to give a portfolio at time zero that will have the same value as the underlying real asset.

[8] See McDonald and Siegel [48, p. 710] for this point.

[9] This is why $\delta = 0$ in the Black and Scholes [5] option pricing formula for a non-dividend-paying stock.

[10] For an excellent discussion of this point, see McDonald and Siegel [47, p. 338].

[11] See Friedman [29, p. 148] for a mathematical proof of the solution technique.

[12] This and some following results in the paper involve lengthy and tedious algebraic operations. We present only the final expressions for brevity. The details of derivations are available from the authors upon request.

B. Market Beta as a Function of Growth Opportunities

The market beta of the firm's equity (β_M) is the weighted average of the beta of equity associated with assets in place (β_{EA}) and the beta of growth opportunities (β_G):

$$\beta_M = (VEA/VE)\beta_{EA} + (PVGO/VE)\beta_G . \tag{5}$$

In Equation (5), the beta of equity associated with assets in place is defined as:

$$\beta_{EA} = COV(ROE, ROE_M)/VAR(ROE_M) ; \tag{6}$$

where ROE is the return on equity generated from assets already in place and ROE_M is the market equivalent of ROE.

On the other hand, β_G is the weighted average of betas of all future growth opportunities:

$$\beta_G = \sum \{VG(t, 0)/PVGO\}\beta_{Gt} . \tag{7}$$

In Equation (7), the risk of the growth opportunity at time t, β_{Gt}, is defined as:

$$\beta_{Gt} = COV(R_{Gt}, R_{Mt})/VAR(R_{Mt}) ; \tag{8}$$

where R_{Gt} is the instantaneous return on the growth opportunity (i.e., dVG/VG) and R_{Mt} is the instantaneous return on the market portfolio.

Note that, in the limit (i.e., as dt approaches zero), R_{Gt} is defined as (see Galai and Masulis [31, p. 58]):

$$R_{Gt} = (VG_x/VG)\, xR_{xt} ; \tag{9}$$

where VG_x is the partial derivative of VG with respect to x and $R_{xt} = dx/x$. Since it can be shown from Equation (3) that $VG_x = e^{\delta t}N(d_{1t})$, Equation (9) can be rewritten as:

$$R_{Gt} = \{e^{\delta t}N(d_{1t})\, x(0)/VG(t, 0)\}R_{xt} . \tag{10}$$

Substituting Equation (10) into Equation (8) we obtain:

$$\beta_{Gt} = \{e^{\delta t}N(d_{1t})\, x(0)/VG(t, 0)\}\beta_{xt} , \tag{11}$$

where $\beta_{xt} = COV(R_{xt}, R_{Mt})/VAR(R_{Mt})$.

Next, substituting Equation (11) into Equation (7), we obtain:

$$\beta_G = \sum \{VG(t, 0)/PVGO\}\beta_{Gt} . \tag{12}$$

If the firm is assumed to remain in the same business risk class (i.e., all future investment opportunities have the same risk as that of the existing assets, $\beta_{xt} = \beta_{EA}$ for all t), Equation (12) becomes:[13]

$$\beta_G = \beta_{EA} \left[\sum \{e^{\delta t}N(d_{1t})\, x(0)/PVGO\}\right] . \tag{13}$$

Finally, substituting Equation (13) into Equation (5), and after simplification, we obtain:

$$\beta_M = \beta_{EA}[1 + (PVIGO/VE)] ; \tag{14}$$

where $PVIGO$ is the present value of investments in growth opportunities (i.e., $\sum I_t e^{-rt}N(d_{2t})$).[14]

Equation (14) shows that the market beta is comprised of the risk of equity associated with assets already in place (i.e., β_{EA}) and the uncertainty associated with future growth opportunities. For growth firms, the market beta is greater than the beta of equity associated with assets in place, even when the firm is expected to remain in the same business risk class (i.e., $\beta_{xt} = \beta_{EA}$). Economic intuition underlying this result is simple: since the risk of the call option (i.e., the growth opportunity) is greater than that of the underlying asset,[15] and since the market beta is the weighted average of the beta of equity associated with assets in place and the beta of growth opportunities, it follows that the market beta will be larger than the beta of equity associated with assets in place.

The positive relation between the market beta and growth opportunities posited in this study is in sharp

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[13]Miles [49] also made the same assumption.

[14]Note that $I_t e^{-rt}$ is the present value of investment in the growth opportunity available at time t and $N(d_{2t})$ is the probability of undertaking the project. Hence $PVIGO$ can be interpreted as the expected present value of all future investments in growth opportunities. See Copeland and Weston [25, p. 276] for the discussion of intuitive interpretation of $N(d_{2t})$. It should be noted that, in general, $N(d_{2t})$ represents the probability of undertaking the project only if investors are risk-neutral (see Smith [62, p. 23, fn. 22]).

[15]To see this point, remember first from Equation (11) that

$$\beta_{Gt} = N(d_{1t})[x(0)e^{\delta t}/VG(t, 0)]\beta_{xt} .$$

Now, notice that (see Galai and Masulis [31, p. 59])

$$N(d_{1t})[x(0)e^{\delta t}/VG(t, 0)] > 1 .$$

Hence, it follows that $\beta_{Gt} > \beta_{xt}$.

contrast to the results suggested in the market power literature. Earlier, Thomadakis [64], Subrahmanyam and Thomadakis [63], Chen, Cheng, and Hite [21], Ben-Horim and Callen [4], and Lee, Liaw, and Rahman [39] have argued that firms with larger economic rents will have lower market betas and thus lower equity capitalization rates. Specifically, Chen, Cheng, and Hite [21] and Ben-Horim and Callen [4] suggest that an inverse relation exists between the market power as measured by Tobin's q (i.e., the ratio of market value to replacement cost) and the market beta of equity (the cost of equity). Similarly, Thomadakis [64], Subrahmanyam and Thomadakis [63], and Lee, Liaw, and Rahman [39] argue that the firm with the larger market power and thus with the larger positive economic rent will have the lower market beta. On the other hand, Booth [7] and Conine [24] suggest that the relationship between monopoly power and beta could be either positive or negative, depending on relative values of other parameters in the model.

Hence, the prediction of the present study contrasts squarely with the one made by these studies. These contradictory predictions result from the fact that this study views growth opportunities as real options the value of which is yet to be realized by future discretionary decisions of firms (hence riskier than assets in place), whereas the above studies view growth opportunities as the existence of positive economic rents arising from firms' *monopoly power* in factor and/or output markets.[16] Since both the prediction of the present study and that of the above studies are direct implications of internally consistent theoretical constructs, the ultimate verdict on which construct is a more reasonable representation of the real world can only be made by empirical confirmation. In the following sections, we undertake an empirical analysis to answer this question.

II. Data Description and Estimation Procedure

In this and following sections, we present empirical results testing the validity of Equation (14). For the 1979-1988 period, monthly stock returns and accounting data required for the calculation of the market beta and the beta of equity associated with assets in place are obtained from CRSP and COMPUSTAT tapes. Among firms listed in the CRSP and COMPUSTAT tapes, the firms with December fiscal year-end and with all required data (482 firms) are included in the final sample.

The market beta of the firm's equity (β_{Mi}) is estimated using the market model:

$$R_i = \alpha_i + \beta_{Mi} R_M + \epsilon_i \qquad (15)$$

where R_i is the monthly stock return for the firm i from the CRSP return tape, R_M is the value-weighted monthly market return from the CRSP return tape, α_i and β_{Mi} are constants, and ϵ_i is an error term.

From Equation (6), the beta of equity associated with assets in place (β_{EAi}) is estimated using the following regression:

$$ROE_i = a_i + \beta_{EAi} ROE_M + e_i\,; \qquad (16)$$

where ROE_i is the ratio of net income to shareholders in the current period to the book value of equity in the previous period and ROE_M is the market equivalent of ROE_i which is calculated as the value-weighted average of ROE_i. We use the book value of equity as the portion of the market value of equity which is accounted for by assets already in place (i.e., *VEA* in Equation (1)). Similarly, we use accounting net income as the proxy for cash flows to shareholders generated from the assets in place. Of course, the book value of equity and accounting income are undoubtedly imperfect proxies for *VEA* and cash flows. For example, the fact that corporate managers tend to smooth their reported accounting incomes will make the cash flow proxy imperfect. Nonetheless, as long as the relation between the true ROE_i and its proxy is linear and the errors in the proxy are not correlated with other variables in the regression (there is no strong reason to believe that these assumptions will be seriously violated by the data), measurement errors will not cause a systematic bias in empirical results. The issue of measurement error will be further examined later (in Subsection B of Section III) by performing regression analysis using portfolio grouping procedure.

We assume that firms with larger growth opportunities will make larger investments in growth opportunities. The ten-year average earnings-price ratio (*EP*) is used as the empirical proxy for the firm's growth op-

[16] This is a classic example of the pitfall associated with so-called "economic modernism" pointed out by McCloskey [46]. It illustrates an arbitrariness of predictions of theoretical construct. That is, in McCloskey's words [46, p. 493], "it is trivially easy to draw a diagram that yields the opposite result."

portunities.[17] The earnings-price ratio rather than the price-earnings ratio is used in order to reduce the possible distortion in the proxy measure when the firm experiences a temporary decline in earning that is close to zero or negative.[18] The following two definitions of EP are employed:

$$EP_{1i} = \sum (EPS_{i,t}/P_{i,t})/10\,, \qquad (17)$$

and

$$EP_{2i} = \sum EPS_{i,t}/\sum P_{i,t}\,; \qquad (18)$$

where $EPS_{i,t}$ is the earnings per share for the firm i at time t and $P_{i,t}$ is the firm's closing stock price at time t. In the second definition, the price and earnings per share are summed over the study period before the ratio is calculated in an attempt to mitigate the effect of temporary fluctuation in earnings and price on the growth measure.

The firm's growth opportunity is also measured by the ten-year average ratio of the market to book value of equity:[19]

$$MB_i = \sum (MVE_{i,t}/BVE_{i,t})/10 \qquad (19)$$

where $MVE_{i,t}$ and $BVE_{i,t}$, respectively, are the market and book values of equity for the firm i at time t. Here, the book value of equity is a surrogate for the value of assets in place (i.e., VEA in Equation (1)) and the market value of equity is a surrogate for the combined value of assets in place and growth opportunities (i.e., VE in Equation (1)).

III. Empirical Results

A. Regression Results with Individual Securities

Equation (14) is empirically fitted to examine the relationship between the market beta and the firm's growth opportunities. In order to reflect the nonlinear multiplicative functional specification of Equation (14), we use the logarithmic transformation of Equation (14) in the empirical study:[20]

$$\ln\beta_M = b_0 + b_1\ln\beta_{EA} + b_2\ln(GROWTH) + e\,. \qquad (20)$$

The regression results are presented in Exhibit 1. The first equation reports the results when only β_{EA} is used to explain the cross-sectional variation in the market beta. The second through fourth equations report the results when both β_{EA} and proxies for firms' growth opportunities are used in the regression. The second and third equations use EP_2 and EP_1, respectively, as the proxy for growth opportunities. The fourth equation uses MB as the proxy for growth opportunities.

The regression results show that β_{EA} has a significant positive effect on the market beta. All four coefficients of β_{EA} have the correct sign and are statistically significant at the one percent level. Furthermore, they are robust (i.e., they range from 0.0849 to 0.1139) to the absence/presence of the other explanatory variable, indicating a strong connection between β_M and β_{EA}.

All three estimated coefficients for the firm's growth opportunities (i.e., EP_2, EP_1, and MB) have correct

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[17] We use earnings-price as a proxy for growth opportunities following the tradition of Litzenberger and Rao [41] and Beaver and Morse [3]. The rationale for using EP as the proxy for growth opportunities is clear from the following expression for the market equilibrium price of a common stock: $P = EPS_1/r + PVGO$, where P is the market equilibrium stock price, EPS_1 is the earning per share at time 1 generated from the assets already in place at time 0, r is the capitalization rate, and $PVGO$ is the present value growth opportunities. The first term, EPS_1/r, is the capitalized value of the earning that the firm would generate with the assets already in place, and $PVGO$ is the net present value of the firm's future investment options. A rearrangement of the above equation yields $PVGO/P = 1 - (EP/r)$, where $EP = EPS_1/P$. Differentiating $PVGO/P$ with respect to EP, we obtain $d(PVGO/P)/dEP = -1/r < 0$. Thus the larger the EP, the smaller the ratio of the part of equity value accounted for by growth opportunities, *ceteris paribus*.

[18] When the firm experiences a temporary decline in earning that is close to zero or negative, price-earnings ratio could give distorted results, whereas earnings-price ratio is more robust to the possible distortion. Suppose, for example, that the firm A's stock prices at time t_1, t_2, and t_3 were \$70, \$60, and \$75, and earnings per share for corresponding periods were \$5, \$4.5, and \$6, respectively. Suppose also that the firm B's stock prices were same as those of the firm A but firm B experienced a temporary decline in earning at t_2 and thus its earnings per share for corresponding periods were \$5, \$0.1, and \$6, respectively. Then the average price-earnings ratio for each firm is $PE_{1A} = 13.28$ and $PE_{1B} = 208.8$, whereas the average earnings-price ratios are $EP_{1A} = 0.075$ and $EP_{1B} = 0.051$. Thus the earnings-price ratio is more robust to the temporary decline in earning.

[19] Following Long and Malitz [42] and Bradley, Jarrell, and Kim [10], we also use the ten-year average research and development (R & D) expenditures divided by total assets (or net sales) as a proxy for growth opportunities. Although the regression results indicate that R & D expenditures are positively related to the risk of stock, the statistical significance was low.

[20] Since we take the log of variables, all observations with negative values are excluded in the regression. The number of firms in the final sample is 313. When we run the regression without logarithmic transformation, however, the results are similar to those presented in the paper.

Exhibit 1. The Effect of Equity Beta Associated with Assets in Place and Growth Opportunities on Market Beta

$$\ln \beta_M = b_0 + b_1 \ln \beta_{EA} + b_2 \ln(GROWTH) + e$$

Study Period	b_0	b_1	b_2 [a]	b_2 [b]	b_2 [c]	*F*-Value	Adjusted R^2
1979-1988	-0.0166	0.1113				59.41**	0.172
	(-0.87)	(7.71**)					
	-0.6544	0.0849	-0.2586			42.69**	0.228
	(-4.73**)	(5.64**)	(-4.65**)				
	-0.2119	0.1122		-0.0831		33.48**	0.187
	(-2.67*)	(7.84**)		(-2.53*)			
	-0.0784	0.1139			0.1625	39.82**	0.216
	(-3.29**)	(8.10**)			(4.11**)		

[a] When EP_2 is used as the proxy for *GROWTH.*
[b] When EP_1 is used as the proxy for *GROWTH.*
[c] When the market over book value of equity is used as the proxy for *GROWTH.*
The figures in parentheses are *t*-values.
*Statistically significant at the 5% level.
**Statistically significant at the 1% level.

signs and are statistically significant. The model explains 18.7 to 22.8% of the cross-sectional variation in the market beta. Overall, the empirical results suggest that not only the risk inherent in existing assets but also the risk arising from the firm's future investment opportunities are important determinants of the risk borne by current shareholders.

It should be noted, however, that *(i)* large capitalization firms tend to have low market betas (see, e.g., Goodman and Peavy [32] and Booth and Smith [8]), and *(ii)* the price-earnings ratio and market/book equity ratio are generally high for large capitalization firms (see, e.g., Keim [35]). Hence, one may conjecture that the positive empirical relation between β_M and growth variables found in this paper may be a spurious one. That is, it may in fact merely represent the negative relationship between firm size and β_M. One way to examine this possibility is to include a size variable in the regression and to see whether growth variables still provide any additional explanatory power. This approach should be implemented with some caution, however, since a significant empirical correlation exists between the growth variables and size. For instance, in our sample of firms, the correlation coefficient between market capitalization and the market over book value of equity is 0.42.

In order to eliminate potential multicollinearity and to control for the danger of a simultaneous equation bias arising from the possible correlation of the independent variables with the error term, we regress ln(*SIZE*) against ln(*GROWTH*) for each definition of the growth variable and calculate the residual (*SIZE RESIDUAL*), which is "observed ln(*SIZE*)" minus "ln(*SIZE*) predicted by ln(*GROWTH*)." Since the residual is, by definition, uncorrelated with ln(*GROWTH*), replacing ln(*SIZE*) by the residual in the regression equation addresses both problems of multicollinearity and simultaneous equation bias. Thus, the following regression equations are estimated using the residual:

$$\ln \beta_M = b_0 + b_1 \ln \beta_{EA} + b_2 \ln(GROWTH) + b_3(SIZE\ RESIDUAL) + e\,. \quad (21)$$

The regression results are presented in Exhibit 2. The results indicate that the coefficients for the size residual are not significantly different from zero and adding the size residual to the regression does not improve the explanatory power. It is also worth noting that the presence of the size residual does not affect the magnitude of the coefficients for β_{EA} and growth variables. Remembering that the coefficients for ln(EP_2),

Exhibit 2. The Effect of Equity Beta Associated with Assets in Place, Growth Opportunities, and Size on Market Beta

$$\ln\beta_M = b_0 + b_1\ln\beta_{EA} + b_2\ln(GROWTH) + b_3(SIZE\ RESIDUAL) + e$$

Study Period	b_0	b_1	b_2 [a]	b_2 [b]	b_2 [c]	b_3	F-Value	Adjusted R^2
1979-1988	-0.6582	0.0837	-0.2602			0.0190	29.19**	0.231
	(-4.76**)	(5.57**)	(-4.68**)			(1.39)		
	(-2.66**)	0.1123		-0.0831		0.0050	22.29**	0.185
	(-4.73**)	(7.844**)		(-2.53*)		(0.36)		
	-0.0784	0.1139			0.1625	-0.0058	26.53**	0.214
	(-3.28**)	(8.09**)			(4.10**)	(-0.42)		

[a]When EP_2 is used as the proxy for *GROWTH*.
[b]When EP_1 is used as the proxy for *GROWTH*.
[c]When the market over book value of equity is used as the proxy for *GROWTH*.
The figures in parentheses are t-values.
*Statistically significant at the 5% level.
**Statistically significant at the 1% level.

$\ln(EP_1)$, and $\ln(MB)$ are -0.2586, -0.0831, and 0.1625, respectively, when the size residual is ignored in the regression (see Exhibit 1), and noting that corresponding coefficients are -0.2602, -0.0831, and 0.1625 when the size residual is included in the regression, it seems that the presence of firm size does not change the effect of growth on the market beta in any meaningful proportion, after correcting the multicollinearity problem. Thus, it appears that the effect of growth on stock risk is quite independent of firm size.

B. Portfolio Grouping Approach

Although we obtain the expected signs for the estimated coefficients in a cross-sectional regression at the individual firm level, the magnitude of the estimated coefficients may be biased due to measurement errors.[21] For instance, we use the accounting net income in calculating β_{EA}, although β_{EA} is theoretically defined in terms of cash flows. Given the observation that corporate managers tend to smooth their reported accounting incomes, there may be a substantial discrepancy between the net cash flow and accounting income and this may cause significant measurement error.

It is well known that measurement of variables at the portfolio level can provide much more precise estimates of true values than the measurement of variables at the individual firm level as long as the errors in the explanatory variables are substantially less than perfectly positively correlated.[22] In order to reduce the loss of information caused by using portfolios rather than individual securities, a wide dispersion of the values of explanatory variables at the portfolio level can be obtained by forming portfolios on the basis of ranked values of the instrumental variables for the explanatory variables. Following the spirit of Fama and MacBeth [28], we use the values of β_M, β_{EA}, *GROWTH*, and *SIZE RESIDUAL* from the previous period as the instrumental variables. That is, when we group the securities into portfolios using β_M, we use β_M computed from the 1969-1978 data as the instrumental variable for β_M of the 1979-1988 period. The same procedure is used to construct portfolios of five and ten

[21]See Kmenta [38] for the discussion of downward bias problem associated with the ordinary least square procedure when variables are measured with error.

[22]See Black, Jensen, and Scholes [6] and Fama and MacBeth [28] for the in-depth discussion of the portfolio grouping approach and its statistical merits.

Exhibit 3. The Effect of Equity Beta Associated with Assets in Place, Growth Opportunities, and Size on Market Beta

$$\ln\beta_M = b_0 + b_1\ln\beta_{EA} + b_2\ln(GROWTH) + b_3(SIZE\ RESIDUAL) + e$$

The number of securities in each portfolio = 5

Instrumental Variable	b_0	b_1	b_2 [a]	b_2 [b]	b_2 [c]	b_3	F-Value	Adjusted R^2
β_M	-0.9802	0.1546	-0.3664			-0.0536	14.19**	0.442
	(-3.94**)	(4.31**)	(-3.69**)			(-1.58)		
	-0.3791	0.1650		-0.1178		-0.0633	11.04**	0.376
	(-2.98**)	(4.37**)		(-2.51*)		(-1.78)		
	-0.1978	0.1648			0.2722	-0.0838	12.75**	0.414
	(-3.52**)	(4.54**)			(2.67**)	(-2.46*)		
β_{EA}	-0.7164	0.0881	-0.2787			0.0116	11.30**	0.387
	(-2.80**)	(3.02**)	(-2.72**)			(0.36)		
	-0.1497			-0.0471		0.0073	8.06**	0.302
	(-1.15)	(3.79**)		(-0.98)		(0.21)		
	-0.1564	0.1210			0.2996	-0.0133	13.81**	0.440
	(-3.58**)	(5.03**)			(3.52**)	(-0.42)		
GROWTH	-0.4515	0.0328	-0.1587			0.0197	2.48	0.077
	(-2.11*)	(1.28)	(-1.84)			(0.67)		
	-0.2862	0.0904		-0.0783		0.0069	4.13**	0.153
	(-3.48**)	(2.47*)		(-2.62*)		(0.23)		
	-0.1083	0.0378			0.0870	-0.0530	2.81*	0.095
	(-3.69**)				(1.73)	(-2.06*)		
SIZE	-0.9010	0.0629	-0.3367			0.0194	8.94**	0.310
RESIDUAL	(-2.92**)	(2.33*)	(-2.62*)			(1.18)		
	-0.4842	0.0734		-0.1600		0.0188	7.47**	0.268
	(-2.35*)	(2.68**)		(-1.90)		(1.10)		
	-0.1141	0.0994			0.0478	0.0066	5.67**	0.209
	(2.88**)	(3.96**)			(0.58)	(0.36)		

[a]When EP_2 is used as the proxy for *GROWTH.*
[b]When EP_1 is used as the proxy for *GROWTH.*
[c]When the market over book value of equity is used as the proxy for *GROWTH.*
The figures in parentheses are t-values.
*Statistically significant at the 5% level.
**Statistically significant at the 1% level.

securities using β_{EA}, EP_1, EP_2, *MB*, and *SIZE RESIDUAL.*

Exhibits 3 and 4 present regression results when each portfolio contains five and ten securities, respectively. In both tables, four sets of regression results are provided. Each panel reports the regression results when portfolios are constructed based on instrumental variables for β_M, β_{EA}, *GROWTH*, and *SIZE*

Exhibit 4. The Effect of Equity Beta Associated with Assets in Place, Growth Opportunities, and Size on Market Beta

$$\ln\beta_M = b_0 + b_1\ln\beta_{EA} + b_2\ln(GROWTH) + b_3(SIZE\ RESIDUAL) + e$$

The number of securities in each portfolio = 10

Instrumental Variable	b_0	b_1	b_2 [a]	b_2 [b]	b_2 [c]	b_3	F-Value	Adjusted R^2
β_M	-0.8812	0.2588	-0.3238			-0.0810	35.17**	0.792
	(-3.14**)	(5.83**)	(-2.92**)			(-1.60)		
	-0.4026	0.2883		-0.1260		-0.1071	31.90**	0.775
	(-2.71*)	(7.08**)		(-2.30*)		(-2.19*)		
	-0.2151	0.2865			0.3014	-0.1156	35.23**	0.792
	(-3.36**)	(7.79**)			(2.55*)	(-2.65*)		
β_{EA}	-1.1991	0.1470	-0.4664			0.0438	15.07**	0.601
	(-4.44**)	(4.84**)	(-4.30**)			(1.08)		
	-0.6697	0.1560		-0.2425		0.0442	11.84**	0.537
	(-3.72**)	(4.77**)		(-3.52**)		(1.01)		
	-0.1681	0.1530			0.2636	-0.0302	6.81**	0.384
	(-2.29*)	(4.06**)			(1.89)	(-0.56)		
GROWTH	-0.5115	0.0516	-0.1803			-0.0048	3.93*	0.239
	(-2.01)	(2.22*)	(-1.76)			(-0.10)		
	-0.5539	0.1300		-0.1894		0.0650	8.81**	0.438
	(-2.46*)	(3.10**)		(-2.13*)		(1.64)		
	-0.1509	0.1201			0.1608	-0.0529	3.95*	0.254
	(-3.86**)	(2.92**)			(2.38*)	(-1.25)		
SIZE	-0.6030	0.0492	-0.2114			0.0289	6.75**	0.365
RESIDUAL	(-2.88**)	(2.06*)	(-2.46*)			(1.79)		
	-0.1429	0.0675		-0.0206		0.0160	3.55*	0.203
	(-2.12*)	(2.63*)		(-0.85)		(0.89)		
	-0.2029	0.0706			-0.2588	-0.0151	5.29**	0.300
	(-3.59**)	(3.02**)			(2.17*)	(-0.86)		

[a]When EP_2 is used as the proxy for *GROWTH.*
[b]When EP_1 is used as the proxy for *GROWTH.*
[c]When the market over book value of equity is used as the proxy for *GROWTH.*
The figures in parentheses are t-values.
*Statistically significant at the 5% level.
**Statistically significant at the 1% level.

RESIDUAL, respectively. The first, second, and third equations in each panel report regression results when EP_2, EP_1, and *MB*, respectively, are used as the proxy for growth opportunities.

Notice first that all the estimated coefficients have correct signs. The results show that earnings-price ratio is negatively related to the market beta and the market over book value of equity is positively related to the market beta, both indicating that firms with greater growth opportunities have a higher risk of shareholders. As expected, the more the number of securities is included in each portfolio, the larger the R-square. It is particularly impressive to note that more than three-quarters of the cross-sectional difference in the market beta is accounted for by the difference in β_{EA}, *GROWTH*, and *SIZE RESIDUAL* when portfolios are formed using β_M as an instrumental variable and each portfolio contains ten securities (see the first panel of Exhibit 4). This relatively high explanatory power of the model may be attributable partly to the reduction of measurement errors described above and partly to the pure statistical artifact of aggregation (i.e., explanatory power of a regression model using average values of variables will be greater than that using original values). When portfolios are formed based on β_{EA}, *GROWTH*, and *SIZE RESIDUAL*, respectively, overall results are similar to those of the first panel, although the explanatory power of the model is somewhat low.

It is worth noting, when portfolios are formed based on the instrumental variable for β_M, that absolute values of the estimated coefficients using portfolio data are larger than those using individual security data. This result indicates that the portfolio grouping procedure indeed reduces the measurement errors, and as a result, the downward bias problem has been corrected to a certain extent, although the results are not as dramatic as expected. When portfolios are formed by other instrumental variables, however, the results are mixed.

IV. Summary

The hypothesis presented in this paper is simple and intuitive. In essence, it states that the greater the portion of a stock's value accounted for by the value of future discretionary investment options, the higher the stock risk, *ceteris paribus*. For instance, a high-tech firm that has a large portion of its value accounted for by the present value of future growth opportunities, would exhibit a higher stock risk than the mature firm whose value is largely determined by the capitalized value of an earnings stream generated by existing assets. Overall, our empirical results strongly support this hypothesis. The results show that a positive empirical relation exists between the firm's equity beta and various measures of growth opportunities. The results also show that introducing firm size into the regression analysis does not affect the empirical relation between the stock beta and growth variables in any significant fashion. Thus, it appears that the effect of growth on stock risk is independent of firm size.

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