# Predicting Systematic Risk: Implications from Growth Options

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# Predicting Systematic Risk: Implications from Growth Options

**Abstract**

Price changes can be associated with either increases or decreases in systematic risk. The well-known financial leverage effect suggests that decreases in stock prices increase the levered equity beta. However, as growth options are more volatile and have higher risk than assets in place, a price decrease may decrease the unlevered equity beta via an "operating leverage" effect. This is because decreases in prices are associated with a proportionately higher loss in growth options than in assets in place. Most of the existing literature focuses on the financial leverage effect. This paper examines both effects. Our empirical work indicates that, contrary to common belief, the operating leverage effect largely dominates the financial leverage effect, even for highly levered firms that presumably have fewer growth options. We then link variations in betas to measurable firm characteristics that proxy for the proportion of the firm invested in growth options. Finally, we show that these proxies allow to predict a large fraction of cross-sectional differences in betas. Our results have important implications on the predictability of equity betas, hence on portfolio management techniques that use measures of systematic risk.

# 1 Introduction

The measurement of systematic risk (beta) is a cornerstone of empirical asset pricing. It is essential for portfolio and risk management in addition to tests of models of risk versus return and market efficiency. Various anomalies that have recently appeared in the literature have triggered a renewed interest in the determinants of systematic risk. Specifically, the extent to which these returns reward exposure to risk or are abnormal is at the center of the discussion. The proper measurement of systematic risk is therefore central for the study of the various anomalies, mutual fund performance as well as the performance of more complicated hedge fund strategies.

Consider for example, the results in DeBondt and Thaler (1985) who show that stocks that are long term winners (losers) tend to perform poorly (well) over the subsequent three to five year period. They argue that this reversal pattern supports the hypothesis that stock prices tend to overreact to information. However, Chan (1988), Ball and Kothari (1989) and others, argue that the higher subsequent returns of the losers are likely due to increased systematic risk. In effect, they invoke the original financial leverage hypothesis in Hamada (1972) and Rubinstein (1974), whereby decreases in equity value result in higher financial leverage and, in turn, in higher levered equity betas. DeBondt and Thaler (1987) and Chopra et al. (1992) counter that such changes in beta cannot fully explain the asymmetry in return reversals, where the subsequent loss of past winners is far smaller than the subsequent gain of past losers.[1] In contrast with the financial leverage hypothesis, we will see below that growth options could predict a decrease in the equity betas of losers. Despite the intense debate on the nature of this well known reversal, this latter possibility is not explored in the empirical literature.

Although the sole purpose of our paper is not the explanation of return reversals, it is clear that to evaluate performance one must first understand changes in systematic risk. This is especially crucial for extreme performers whose risk exposure may have changed. Ex-ante determinants of systematic risk received attention in the early literature.[2] However, following Fama and

[1] Ball et al. (1995) show that illiquid low share prices substantially drive the return reversals of past losers, which may explain the asymmetry.

[2] For example, Beaver, Kettler and Scholes (1970) use accounting measures to predict market betas. Rosenberg (1974) relate the loadings of individual security returns on risk factors to firm characteristics. Rosenberg and McK-

Mc.Beth (1973), most of the empirical asset pricing and portfolio literature uses simple time series methods such as rolling windows to capture variations in betas.

A more recent literature uses more sophisticated time-series techniques to allow for the time-variation of risk parameters. It has met with somewhat disappointing results. For example, Braun, Nelson and Sunier (1995) incorporate financial leverage on a GARCH model of time varying betas. They report very little gain in forecasting efficiency. Similarly, while Bekaert and Wu (2000) uncover strong leverage effects on asset and asymmetries in volatilities, there is no such evidence on betas. In contrast, this paper studies directly, mostly in the cross-section, variations in long-term betas following from the two major competing hypotheses of financial and operating leverage.[3]

To better understand the implications of growth options on betas through the operating leverage effect, we consider a simple model as follows. Assume that the firm is a portfolio of growth options and assets in place. The unlevered asset beta of the firm is then a weighted average of the betas of growth options and assets in place. Since growth options require more future discretionary investment expenditures than assets in place, they resemble more out-of-the money options. Therefore, they have higher betas. So, an increase in the value of the firm's underlying assets[4] will have a stronger impact on growth options, and will increase the fraction of the total value accounted by growth options. By this "change-in-mix" effect, an increase in the firm's market value is associated with an increase in its asset beta. However, we will see in section 2 that a second effect possibly offsets this: As the value of the underlying asset increases, a resulting increase in "moneyness" causes the betas of all the options in the firm to decrease . Finally, for a given unlevered beta, the well known financial leverage effect causes the levered beta to increase with the debt to equity ratio.

Section 2 describes a simple model of the firm with growth options. The model implies that, for a plausible range of ratios of growth opportunities to assets in place, the "change-in-mix" effect should dominate the "moneyness" effect. Further, our empirical results show that the "change-in-mix" effect also dominates the better known financial leverage effect. Specifically, we find that

ibben (1973) and Rosenberg (1985) use firm characteristics to predict risk.

[3]See Cao et al. (2004) for the implications of growth options on the time series of idiosyncratic risk.

[4]That is, the projects on which the firm has options.

betas are highly related to proxies for the fraction of the firms' assets in growth options. First, firms with high growth options have higher equity betas. Second, after long-term changes in stock prices, the levered equity betas of losers decrease and those of winners do not change.[5]he patterns in levered equity betas which we uncover allow us to infer the corresponding changes in unlevered betas without the need for specific functional relationship between the two. This is consistent with the conclusion of Chopra et al. (1992) that the patterns of change in the betas of winners and losers contradict the financial leverage hypothesis.

We examine the robustness of this conclusion to the initial level of financial leverage. First, financial leverage is likely to have the strongest effect on betas for the most highly levered firms. Second, one may suspect that highly levered firms tend to have few growth options - we confirm this empirically. Hence, for these firms, the change-in-mix effect may not dominate. However, we find that even firms with initially high leverage and low growth options experience decreases after losses.

Changes in betas arising from drastic changes in market values raise the question of how fast the market accounts for them. Indeed, while most market participants understand financial leverage mechanics, implications from real options theory are not so well understood. For example, investors less familiar with real option could initially ascribe a financial leverage effect on the betas of recent losers. Therefore, these loser stock prices would overreact to subsequent index movements if their betas remain too high for too long. Then only, with further information slowly coming to the market, would the implications of the loss in growth options be factored into the equity beta. Our empirical evidence is consistent with this scenario. Specifically, the annual returns of past losers are negatively correlated with the lagged market returns, suggesting that these stocks may have previously over-reacted to contemporaneous market returns.

The paper proceeds as follows. The second section uses a simple option pricing model to illustrate the effect of market returns on asset betas. Section 3 describes the data and the methodology. Section 4 contains the empirical results and analysis. Section 5 concludes.

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## 2 Growth Options and Unlevered Equity Betas

This section uses a simple option-pricing model to examine how unlevered betas are likely to respond to changes in firm values. In the model, firms consist of assets already in place and future growth options that require additional investments. Since the firm is not required to make these future investments, growth options can be viewed as call options to acquire an asset at an exercise price equal to the required investment.

To understand how the betas of different growth options differ from each other and from assets in place, consider the equity value $G$ of a firm with an option to undertake a project of value $s$ and beta $\beta_s$ at an investment cost $C_G$. First, Galai and Masulis (1976) show that the beta of this opportunity is $\beta_G = \eta_G \beta_s$, where $\eta_G$ is the elasticity of the option. Second, we show in the appendix that $\frac{\partial \eta_G}{\partial (s/C_G)}$ is negative. Therefore, given $\beta_s$, the growth opportunity beta, $\beta_G$, decreases as moneyness increases. This implies that growth options have higher betas than assets in place which are effectively very deep in the money options.[6]

Now consider a firm with a portfolio of both growth options and assets in place. [7] Specifically, the firm value is $V = V_A + V_G = AN_A + GN_G$, where $A \equiv A(s), G \equiv G(s)$ are the (option) value of a growth opportunity and an asset in place, and $N_A, N_G$ are the number of such options held by the firm.[8] The asset in place $A(s)$ is a deep in-the-money option with investment cost $C_A \ll s$. Similarly, $G(s)$ is an out-of-the-money option with $C_G > s$ where $s$ is a state variable that determines the value of the different investments. For example, $s$ may be related to price of oil and $A$ and $G$ could represent producing oil wells and undeveloped oil property.[9] In this case,

[6]Some evidence supports this view. For example, Chung and Charoenwong (1991) use contingent claims analysis to decompose systematic risk into parts associated to AIP's and GOP's. They argue that the beta of the GOP's fraction of equity is greater than that of the AIP fraction. Skinner (1993) reports that firms with relatively more growth options tend to have higher asset betas.

[7]Myers (1977) describes the firm as a combination of assets already in place and growth options. As he notes, the distinction between assets in place and growth options is more of degree than kind. The market value of most assets can be partly attributed to associated call options from discretionary decisions. For example even typical assets in place such as property, plant and equipment are subject to discretionary maintenance decisions. So, a small fraction of their value may be akin to growth options.

[8]This formulation allows us to distinguish between firms with many deep out-of-the-money options and those with a few slightly out-of-the-money options.

[9]Berk, Green and Naik (1999) model the firm value in terms of fundamental state variables. In their model growth options are explicitly priced as options which value is affected by state variables, e.g., interest rates, as well as cash flows. Here we let $s$ be exogenous.

the unlevered equity beta equals:

$$\beta_V = \frac{V_A\beta_A + V_G\beta_G}{V} = \frac{AN_A\beta_A + GN_G\beta_G}{V} \tag{1}$$

Now consider the effect of news about the value of $s$, while $N_A$ and $N_G$ are unchanged. In our oil analogy, this would be information about the price of oil and not the amount of oil in the ground. Good news about $s$ increases both $A$ and $G$, but the overall effect on $\beta_V$ is unclear since $\beta_A$ and $\beta_G$ decrease, as seen above. To see this, we write $\frac{d\beta_V}{ds}$.

$$\frac{d\beta_V}{ds} = \frac{GN_G}{V}\beta_G' + \frac{AN_A}{V}\beta_A' + N_G\frac{\beta_G - \beta_V}{V}G' + N_A\frac{\beta_A - \beta_V}{V}A',$$

where $G', A', \beta_G', \beta_A'$ are the derivatives of $G, A, \beta_G, \beta_A$ with respect to $s$. Recall that $\beta_i = \eta_i\beta_S$ for $i$ equal to $G$ or $A$, replace $\beta_V$ with (1), and it can be shown that

$$\frac{V}{\beta_S}\frac{d\beta_V}{ds} = GN_G\eta_G' + AN_A\eta_A' + [\eta_G - \eta_A]^2\,\frac{N_AN_GA'G's}{V}. \tag{2}$$

While the first two terms are negative, the third term is positive.

As the following numerical example illustrates, the sum of these terms can be positive for a wide range of moneyness $s/C_G$ and weights in growth options $V_G/V$. The example assumes: $C_A = 0.1, C_G = 100, s \in [2, 90]$. We also assume without loss of generality, $N_A = 1$, a risk free rate of zero and a variance to maturity $\sigma^2T = 1$. For this range of $s$, the asset in place is always very far into the money. The growth opportunity is always out of the money even when s is 90. The amount of growth options relative to assets in place held also matters. To cover a wide range in the proportion of firm value, $V_G/V$, held in growth options, we use three values of $N_G = 5, 10, 20$.

The bottom panel in figure 1 plots the weight of the firm in growth options, $V_G/V$ versus $s/C_G$, the moneyness of G. The three curves correspond to $N_G = 5, 10, 20$. The plots confirm that these values of $N_G$ bracket a wide range of weights in growth options. For example, for a moneyness ratio $s/C_G$ around 20%, $V_G/V$ varies from 20% to 60%. The key here is that this wide range of values has no effect on the pattern uncovered by the top plot, $\beta_V$ versus $s/C_G$.

The three curves in the top panel in figure 1 have the same shape, with only variations in the location of their minimum and maximum. There are three regions. First, on the left, the growth options are very far out of the money, and hence worth very little. There, an increase in $s$ decreases $\beta_V$. Second, on the right, when the growth options are getting closer to the money and make a large fraction $V_G/V$ of the firm, an increase in $s$ also decreases $\beta_V$. The common link between these two regions is that the firm is actually homogeneous in the type of options held, nearly all in or nearly all out-of-the money. In contrast, in the middle region, an increase in $s$ actually increases $\beta_V$. In the middle region, the firm is the most heterogeneous with close to a fifty-fifty mix of $V_G$ and $V_A$.

We now consider news about $N_G$ and $N_A$, the scale of the growth options and assets in place. Analysts regularly revise their assessment of $N_A$ and $N_G$. Since growth options are harder to precisely measure, it is reasonable to assume that $N_G$ is more volatile than $N_A$. From (1), it follows that

$$\frac{\partial \beta_v}{\partial N_G} = \frac{GV_A}{V^2}(\beta_G - \beta_A). \tag{3}$$

That is, an increase in $N_G$ causes an increase in the asset beta. $\frac{\partial \beta_V}{\partial N_A}$ follows by simply swapping indices $_A$ and $_G$ in (3). Hence, an increase in $N_A$ causes a decrease in beta. Joint revisions $\Delta N_A, \Delta N_G$ in the same direction have opposite effects on $\beta_V$. The combined effect is given by the total derivative of $\beta_V$:

$$d\beta_V = \frac{\beta_G - \beta_A}{V^2}\,(GV_A\Delta N_G - AV_G\Delta N_A).$$

For example, in the case of joint good news, we obtain the condition:

$$d\beta_V > 0 \iff \frac{\Delta N_G}{\Delta N_A} > \frac{N_G}{N_A}. \tag{4}$$

Note that (4) can be rewritten in terms of dollar values $V_G, V_A$. In any case, the ratio of the increases must be larger than the current ratio of growth options over assets in place. For joint bad news, the right hand side of (4) is a condition for $d\beta_V < 0$.

To summarize, unlevered equity betas can plausibly be positively or negatively correlated with firm values. The relation between firm values and betas depend on the mix between growth options and assets in place, the sensitivity of their values to changes in the underlying state variable, and the extent to which stock price movements are generated by information about new or expanded growth options. In addition, the well-known financial leverage effect would cause a decrease in the levered beta relative to the unlevered beta in case of good news.

## 3 Data, Proxies and Methodology

We collect monthly stock returns from 1965 to 1999 for all non-financial firms from the CRSP database . We use the 30-day U.S. Treasury bill return as the risk-free rate. We compute annual rolling betas using three years of monthly excess returns from 1965-67 to 97-99 (33 such periods). For each firm i, we estimate equal- and value-weighted betas, $\beta_{i,EW}, \beta_{i,VW}$, with the usual market model regression on excess returns where the index is the equal or value weighted CRSP index. We also estimate $\beta_{i,MKT}, \beta_{i,SMB}, \beta_{i,HML}$, the Fama-French factor betas, with the regression

$$r_{it} = a_i + \beta_{i,MKT}\, r_{MKT,t} + \beta_{i,SMB}\, r_{SMB,t} + \beta_{i,HML}\, r_{HML,t} + \epsilon_{it}, \quad t = 1, ..., 36,$$

where $r_{MKT}, r_{SMB}, r_{HML,t}$ are the excess returns on the Fama-French, market, size, and book-to-market factors. The factor returns are obtained from Ken French's Web site.

As the weights of firms in growth options and assets in place are not directly observable, we characterize them by using several proxies motivated in the literature and again below, each with some qualities and limitations.

The first proxy for growth options is the ratio of market to book value of assets (**Mb**). It is similar to the reciprocal of the ratio of book value of assets to total firm value (A/V) used by Smith and Watts (1992). The higher Mb is, the higher the ratio of growth options to firm value. Smith and Watts note that the A/V ratio may have measurement problems for firms with long lived assets because assets are measured at historical cost less depreciation. This caveat applies to the Mb ratio. Hence, we also use other proxies.

The second proxy is the ratio of earnings per share to share price (**Ep**), used for example by Kester (1984), Smith and Watts (1992), and Chung and Charoenwong (1991). The larger Ep is, the larger the proportion of equity value attributable to earnings generated from assets in place rather than growth options. This is only valid for firms with non-negative earnings. When forming proxy deciles, we put the firms with negative earnings in a separate group. Ep and Mb are growth measures very often used in the literature.

The third proxy is research activity, R&D. Various measures of research activity are used in the literature. They lead to a large amount of missing data as more than half the firms do not report R&D. Instead, we use the ratio of capital expenditures to net fixed assets (**Capx**). The higher capital expenditures are, the greater the investment made by a firm to create new products, and therefore the greater the growth options.

The fourth proxy is the dividend yield (**Div**). Dividends are linked to investment through the firm's cash flow identity. Jensen (1986) argues that firms with more growth options have lower free cash flows and pay lower dividends. It has been shown in some studies that growth firms tend to have lower dividend yields than non-growth firms. When making deciles, zero-dividend firms are put in a separate group. The other firms are spread over the remaining 9 groups.

We also use the debt to equity ratio, (**Dtoe**). Contracting theory implies that firms with significant growth options may have lower financial leverage because equity financing controls the potential under-investment problem associated with risky debt, see Myers (1977). Here, we track Dtoe mainly to infer changes in unlevered betas from changes in observed levered equity betas.

In summary, high growth opportunity firms are expected to have higher Mb and Capx ratios and lower Ep, Div, and Dtoe ratios. We obtain the needed data items for the computation of these ratios from the merged COMPUSTAT annual industrial files. We update the proxies annually from 1967 to 1999 for each firm, using the latest available data for any three-year period. For example, for the 1967 proxy value, we first look for a value in 1967, then in 1966 and 1965 if needed. If no value is available in this three-year period, it is considered missing.

Every 3-year "ranking" period, we assign firms to deciles in two possible ways as needed for the discussion: (i) on the basis of the three-year cumulative or risk-adjusted returns, or (ii) by growth proxies. We also compute betas, proxies and returns for the three-year periods before and after the ranking period, denoted pre- and post-ranking periods. The pre-ranking periods go from 65-67 to 91-93, the post-ranking periods from 71-73 to 97-99. This will serve to highlight the transitory behavior of the betas of winners and losers during the ranking period. Changes from pre- to post-ranking period, are robust to this transitory variation. To be included in the analysis a firm needs beta estimates as well as the data items used to compute the growth proxies for ranking, pre- and post-ranking periods. Unless mentioned otherwise, the statistics reported for a given group and period are averages over the firms in the group over the sample. Analysis with medians produced similar results and are not reported.

# 4 Empirical Results

## 4.1 Betas and financial leverage

### 4.1.1 Pre-ranking vs ranking period

Table 1 summarizes changes in betas and leverage for losers and winners, confirming existing findings and showing some new results. Firms are allocated to deciles on the basis of their cumulative returns during ranking periods as described in section 3. Panel A reports the cumulative returns for each decile in the ranking and pre- and post-ranking periods, referred to as periods 0, -1 and 1. The first three columns, "Ret. in %", show that the typical loser firm experiences a 53% cumulative loss over three years and recovers with a higher than average 68% return over the post-ranking period. The extreme groups, e.g., 1, 2, 9, 10, indeed display the phenomenon documented by DeBondt and Thaler (1985).

Next, we report the average $\beta_{EW}$ for each decile and period. $\beta_{EW}$ is examined in almost all previous studies. We initially ignore period -1 and examine the changes in betas from the ranking to the post-ranking period. These changes are similar to those reported in Chan (1988), Ball and Kothari (1989), and others. The loser $\beta_{EW}$ increases from 0.96 to 1.11 and the winner

$\beta_{EW}$ decreases from 1.34 to 1.12. $\beta_{VW}$ shows the same pattern for winners but does not change for the loser. Further, except for the loser $\beta_{VW}$ that does not change, tests not reported here show that the changes are statistically significant.

However, using the pre-ranking period as a starting point dramatically alters these conclusions. For both winners and losers, panel A shows almost identical pre- and post-ranking $\beta_{EW}$'s. The losers' $\beta_{EW}$ dips during the ranking period and then returns to its pre-ranking value. Similarly, the winners' $\beta_{EW}$ jumps up before returning to a value quite close to the pre-ranking value. The equity betas of the winners and losers have in fact not changed. Betas measured during the ranking period appear transitory, failing to properly characterize the long run systematic risk of losers both before and after their dramatic episode. We return to this point later.

Recall that we deliberately choose to not use specific *"unlevering"* formulas to recover unlevered betas. The results on levered betas and leverage here always allow us to draw unambiguous inference about the direction of the changes in unlevered betas. Specific formulas would allow us to quantify the magnitude of the change, but this would of course be specific to the formula used. In our case, while their $\beta_{EW}$ remains unchanged, the Dtoe of the losers more than doubles from 53% in period -1 to 119% in period 1. The Dtoe of winners decreases from 107% to 53%. Clearly, the winners (losers) unlevered betas have increased (decreased). This conclusion with respect to the unlevered betas is even stronger for the value weighted betas. For the losers, $\beta_{VW}$ decreases from 1.29 to 1.03. For the winners, it hardly increases, from 1.19 to 1.23.[10] For both value and equal weighted betas, changes in levered betas and financial leverage ratios are consistent with large losses of growth options for the losers, and gains for the winners.

[10]Note that $\beta_{EW}$ and $\beta_{VW}$ decline over time for most groups. Yet, one would expect betas to cross-sectionally average to 1, and hence see about as many increases as decreases. This apparent irregularity is due to the within-group equal averaging. As the winners become larger, their increase in beta is more under-weighted in period 1 than in period -1. Likewise, the losers become smaller and their decrease in beta is more over-weighted in period 1. For robustness, we computed value weighted averages of betas, using firm market values at the end of each 3-year period. As expected, for $\beta_{VW}$, we found declines from periods -1 to 1 for groups 1 to 4, and increases for groups 5 to 10. The losers' beta declines from 1.27 to 1.17. The winners' beta increases from 1.23 to 1.29. As our conclusions are not affected, we only report equal averages for comparability with other studies.

### 4.1.2 Fama-French factor betas

For the losers, $\beta_{EW}$ hardly changes while $\beta_{VW}$ decreases. This may be due to the large decrease in market value during period 0, which causes the loser group to become more exposed to a small firm index (the equal-weighted index). Indeed, in period 1, the losers have a larger $\beta_{EW}$ than $\beta_{VW}$. Conversely, the firms in the winner group may have become larger. To better understand this, consider the changes in the Fama-French (1992) factor betas $\beta_{MKT}, \beta_{SMB}, \beta_{HML}$. First, if systematic risk is indeed described by a multiple factor model such as in Fama-French (1992), $\beta_{EW}$ and $\beta_{VW}$ may give an incomplete description of the evolution of systematic risk for losers and winners and $\beta_{MKT}$ is more relevant. Second, changes in $\beta_{HML}$ are interesting in themselves as the HML factor, the difference between returns on high and low book to market equity stocks, should be inversely related to growth. Firms with the highest growth options should have the lowest exposure to the HML factor. $\beta_{HML}$ will help determine if losers have indeed lost growth options. The SMB factor is not a clear growth proxy. Small, young firms may be more growth oriented, while losers that have lost growth options may also be smaller firms than average. Nevertheless, $\beta_{SMB}$ will help understand the difference between $\beta_{EW}$ and $\beta_{VW}$.

Consider panel A in table 1 again. First, although $\beta_{MKT}$ is different from both $\beta_{EW}$ and $\beta_{VW}$, its time variation confirms our conclusions for unlevered betas. $\beta_{MKT}$ decreases from 1.05 to 0.97 for the losers and increases from 0.96 to 1.04 for the winners. It experiences the same transitory dip and hump as $\beta_{EW}$. Second, both $\beta_{HML}$ and $\beta_{SMB}$ increase for the losers and decrease for the winners. This is consistent with the hypothesized changes in growth opportunities and size. The loser group ends up with the highest $\beta_{HML}$, 0.47, consistent with the worst growth options. The winners end up with the lowest $\beta_{HML}$, -0.18. $\beta_{SMB}$ is far larger for the losers than for the winners at the end of period 1, 1.2 vs 0.9. However the pattern is not monotone. $\beta_{SMB}$ is lower for the middle groups than for the winners. This is consistent with the hypothesis that the winners include a number of small growth firms, in fact more small firms than the middle groups.

In summary, the results are robust to the measure of levered systematic risk, i.e., $\beta_{EW}, \beta_{VW}$, used. Namely, the unlevered betas of losers decrease, consistent with lost growth options. The losers' increased exposure to the HML factor is consistent with this loss. Size per se is not a growth proxy, as both winners and losers become more exposed to the SMB factor than average firms. Finally, betas measured during the ranking period are transitory and unrepresentative of systematic risk either before or after the ranking period.

### 4.1.3 Robustness to extreme initial financial leverage

In the previous sections, we find a positive relationship between stock returns and unlevered betas, consistent with the "change-in-mix" effect in equation (4) dominating both the "moneyness" effect and the financial leverage effect. This is also consistent with the range of growth options in the middle region of figure 1. It is then natural to ask whether this result is robust to extreme initial financial leverage.

The financial leverage effect should be stronger for firms with a high initial leverage. Moreover, for these firms, the operating leverage effect can be weak, or might cause an inverse relationship between stock return and beta similar to the left region of figure 1. In essence, firms with very few growth options do not have much more to loose. Therefore, we might observe an inverse relationship between beta and returns for these firms.

To study beta changes among highly levered firms, we group stocks into financial leverage deciles in period -1. We then form period-0 cumulative return deciles for each leverage decile. Panel B in table 1 reports results for leverage deciles, 1, 9, and 10. Consider the first two rows, for leverage decile 1, which are essentially composed of debt-free firms. Their returns over the three periods are very similar to those of average losers and winners. Winner and loser betas change exactly as in the general case. For the losers, the increase in Dtoe, 0 to 26%, allows us to conclude again that unlevered betas have decreased. The winners undergo a small increase in Dtoe, from 0 to 13%, different from the large decrease seen in panel A. Given that both beta and leverage increase by small amounts, unlevered betas may have slightly decreased, if at all. In terms of operating leverage, this is consistent with a firm in the right region of figure 1, where an increase in $s$, i.e., a decrease in operating leverage, causes a small change in $\beta$. It may also mean that for firms with an already high weight in growth options, positive news are unlikely to be related to a further increase in this weight. Namely, the condition (4) may not be met. The $\beta_{HML}$'s in the pre-ranking period -1, -.07 and -.32, confirm that these low leverage firms have high initial growth options. For example, -.07 is akin to the period 1 $\beta_{HML}$ of winner groups 9/10 in panel A.

We now turn to losers and winners in the top decile of initial leverage, with Dtoe of 276% and 386%, respectively. For the winners, $\beta_{VW}$ increases and $\beta_{EW}$ decreases marginally, from 1.12 to 1.08. Given the large reduction in Dtoe, from 386% to 96%, the winners unlevered betas must have increased. Their terminal $\beta_{HML}$, 0.09, corresponds to a period 1 value between groups 7 or 8, well into the middle of the distribution in growth opportunity. They may be firms with very good news on the weight in growth options, condition (4). It is not surprising then that, as average winners, they exhibit a positive relationship between returns and betas.

We can see that even the losers with high initial financial leverage exhibit a positive operating leverage effect. Their $\beta_{EW}$ is unchanged and $\beta_{VW}$ decreases from 1.18 to 1.03. Their financial leverage hardly changes from period -1 to 1. With a constant financial leverage, this decrease in levered $\beta_{VW}$ implies a decrease in unlevered beta, hence a decrease in growth options. Their increase in $\beta_{HML}$ from 0.44 to 0.65 confirms this. In summary, even firms with initially few growth options, which then suffer a further reduction of their value, still exhibit a positive operating leverage effect. This would put them on the central region of the top plot of Figure 1, although one could have assumed that, initially already in the left region and moving further left, they would have displayed a negative relation between beta and returns. The two middle rows of panel B report on the second highest leverage decile (9). Again, the increase in leverage, 138% to 193% for the losers, joint with the decrease in betas show that, as the general population of losers, their unlevered betas decrease.

## 4.2 Transitory components in $\beta$

We now return to the dip of loser betas (hump for the winners) during the ranking period. Consider a simple market index model. A large negative return can be due to a large negative idiosyncratic shock or, if the market return is negative, a high beta. However, most three-year periods in the sample are up-market periods. Therefore, the losers' group likely includes firms with low betas as well as low idiosyncratic returns.

It is sometimes conjectured that the dip in beta is caused by an econometric bias due to estimation during the sorting period. However, this cannot really be the case. Consider a market model regression in excess-return form, with estimates $\beta_i$ and the abnormal excess return $\alpha_i$. The covariance between the estimators $\hat{\beta}_i$ and $\bar{r}_i$ $(\hat{\alpha}_i + \hat{\beta}_i \bar{r}_m)$ can be shown to be zero. Hence, a sort by total returns, $T\bar{r}_i$, is unrelated to estimation errors in $\beta_i$. On the other hand, the winner (loser) betas do go back down (up) in period 1. Then, it must be that the winner (loser) betas have both high (low) permanent and transitory components. Such a transitory component is necessary to explain the humps and dips observed in the sorting period.

Consider sorting firms according to their risk-adjusted return $\hat{\alpha}_i$. While the correlation between $\hat{\alpha}$ and $\hat{\beta}$ is not zero, it is low. For typical annualized mean (0.07) and standard deviation (0.2) of the market excess return, it is about -0.3. So, sorting on alpha should greatly reduce the influence of beta, true or estimated, on the selection of winners and losers. In turn, the transitory hump and dip of winners and losers should be eliminated. The permanent component should also be eliminated so that the winners (losers) should have lower (higher) betas than in Table 1 in all three periods.

Table 2 reports cumulative returns, $\beta_{EW}$ and $\beta_{VW}$ for firms allocated to deciles of $\alpha$. The results confirm our conjectures. First, the transitory component is essentially gone. For the losers, $\beta_{EW}$ hardly changes through the three periods, with corresponding values of 1.22, 1.21, 1.20. The ranking period dip has disappeared. The hump of the winners' $\beta_{EW}$ is very small; 1.09, 1.13, 1.08, compared with 1.19, 1.42, 1.23 in Table 1. Second, the permanent component is also reduced. The losers' $\beta_{EW}$, around 1.12 when ranking by total return, is around 1.21 when ranking by abnormal return. The winners' $\beta_{EW}$, around 1.2 in Table 1, is now around 1.1. We can make similar observations on $\beta_{VW}$. Note also that the conclusions from table 1 are unchanged.

Ranking by abnormal returns nearly eliminates transitory effects on beta, allowing the study of idiosyncratic shocks on growth options. Some may prefer not to use a pre-ranking period because the shorter history requirement allows to keep more firms in the sample. In such a case, ranking on the basis of $\alpha_i$ rather than the total return helps alleviate the transitory effect in beta.

### 4.3 Betas and growth options

The results so far are consistent with the hypotheses that growth options have higher betas, and are more volatile than assets in place. We now concentrate on the first hypothesis. While the previous analysis was akin to a time series study of changes in growth opportunity, we now document the cross-sectional link between betas and firm characteristics argued in section 3 to proxy for growth options. This will also help gauge the quality of these variables as proxies of growth options.

For each proxy, we allocate firms annually to growth opportunity deciles. As discussed in section 3, high market to book (Mb) and capital expenditures (Capx), and low dividend yield (Div) and earnings per share (Ep) are hypothesized to proxy for high growth options. Therefore, deciles are increasing in Capx and Mb but decreasing in Div and Ep. We compute betas annually from the previous thirty six monthly returns. We then average the results over the 30 periods. Table 3 reports average proxy values, returns, beta's and debt-to-equity ratios.

Panel A reports on Capx. The grouping highlights the dramatic cross-section variability in Capx, 5% to 64%, from decile 1 to 10. Further, deciles 1 and 10 have levered $\beta_{EW}$'s of 0.91 and 1.28. Given their Dtoe's of 128% and 45%, this means that the unlevered beta of low Capx stocks is lower than that of high Capx stocks. Identical conclusions follow from $\beta_{VW}, \beta_{MKT}$. Further, the relationship is nearly monotone along proxy deciles. $\beta_{HML}$, argued to be inversely related to growth options, is indeed here inversely related to Capx. $\beta_{SMB}$ has a U-shaped relationship with Capx. This is consistent with the fact that both low and high growth opportunity groups may include small firms.

The second proxy, Mb, leads to similar conclusions. Both proxies display an unambiguous positive relationship between proxy and beta and an inverse relationship between proxy and financial leverage. Therefore, unlevered betas must also have a positive relationship with the growth opportunity proxies. The conclusion is robust to any reasonable relationship between levered and unlevered betas, only requiring levered beta to increase with financial leverage for a given unlevered beta. We can even infer that the positive relationship relationship between growth options and unlevered betas is stronger than that reported with equity betas.

Div and Ep lead to similar conclusions albeit with differences due to the nature of their high growth decile 10. Decile 10 contains the firms with zero dividend and non positive earnings. Zero-dividend firms have high, though not always the highest equity betas. Their $\beta_{HML}$, 0.12, places them somewhere between deciles 6 and 7. While many zero-dividend firms are growth firms, a number are distressed firms. The same observation can be made for decile 10 of Ep which contains firms with negative earnings. While lower Ep ratios can be argued to be related to higher growth options, it is hard to extend the reasoning to negative earnings, especially after the market events of 2000! Indeed both $\beta_{HML}$ (0.24) and Dtoe (116%) indicate that these firms may have few growth options.

The relations observed in Table 3 between growth proxies and, indirectly, unlevered betas are consistent with the hypothesis that higher growth options result in higher betas. Or, considering this hypothesis pretty uncontroversial, the results demonstrate the quality of these observables as proxies for growth options. The results are unchanged if we estimate betas over the three years after the year of measurement of the proxy. This means that this cross-sectional relationship between betas and proxies may have some predictive power on betas. We return to this later.[11]

### 4.4 Cross-sectional variations in betas

The above analysis examines the relationship between betas and proxies one at a time. We now examine the joint ability of the growth opportunity proxies to explain cross-sectional variations in asset betas. To do this, we estimate the regression:

$$\beta_{i,t+1} \;=\; \delta_t \; X_{i,t} \;+\; \gamma_t \; \Delta X_{i,t} + \epsilon_{i,t+1} \;\; i = 1 \ldots 100, \tag{5}$$

where $X$ is the vector of proxies (Mb, Capx, Div, Ep, Dtoe) measured at $t$ and $\Delta X$ is the change in X from $t$ to $t+1$. The rational for including proxy differences is to check if, on average, recent

[11] These results are robust to other variations in methodology such as the use of medians instead of averages. One may also worry about differences in values of proxies across time and industries. We repeated the analysis, standardizing across period and two-digit SIC codes. The results were again not affected.

changes in proxies have marginal explanatory power over the *long-run* values of the proxies.

To reduce measurement errors in beta estimates, we form 100 portfolios during every non-overlapping three-year ranking period from 67-69 to 94-96. $\beta_{i,t+1}$ is the average of the betas of firms in group i during the next three-year post-ranking period. We estimate this regression for $\beta_{EW}, \beta_{VW}, \beta_{MKT}$, as well as $\beta_{HML}$ and $\beta_{SMB}$. As our 100 portfolios contain fewer stocks than the standard 20 or 40 portfolios used in a typical empirical study, the measurement errors in their betas are consequently larger. However, measurement errors on a left-hand side variable do not induce a bias, they only lower the fit of (5). One goal of the regression in (5) is to precisely assess to what extent we can filter out estimation error through the use of growth option proxies. Further, 100, rather than 20 or 40, observations renders the estimation of the slope coefficients in (5) more precise.

For each group, $X_{i,t}$ is computed as the median of proxies for the firms in group $i$ during the ranking period $t$. $\Delta X_{i,t}$ is the median change from three-year ranking period $t$ to post-ranking period $t+1$. To allow for the specificity of zero-dividends, we include a dummy variable $d_{Div}$ equal to 1 if the group has a zero median dividend, and use $(1 - d_{Div})Div$ instead of $Div$. We run (5) as thirty annual non-overlapping cross-sectional regressions. To facilitate an economic interpretation of $\delta$ and $\gamma$, we standardize the proxies, apart from $d_{Div}$, by their cross-sectional mean and variance, recomputed periodically. That is, $\delta$ is the change in $\beta$ for a one cross-sectional standard deviation change in the proxy. This standardization may also be preferable if proxies exhibit strong time trends or changes through the sample period.

Table 4, panel A reports results for the dependent variables $\beta_{EW}$ and $\beta_{VW}$. The column "mean" shows the average of the 30 estimates. $Q_1$ and $Q_3$ are the first and third quartiles of the distribution of the 30 estimates. "#" shows the number of estimates with the expected sign. Next to it is the t-statistic of the average, allowing for three lags of autocorrelation in the time series of estimates. For concision, Panel B reports only the R-squares for $\beta_{MKT}, \beta_{HML}, \beta_{SMB}$.

The first clear result, by inspection of the R-squares is that the fit is very high. The proxies explain a large fraction of the cross-section of systematic risk. Inspection of the R-squares in both panels produces two clear results. For $\beta_{EW}$, the R-square averages 66%, with three quarters above

62%. For $\beta_{VW}$, the average R-square is 54% with three quarters above 39%. Panel B shows similar magnitudes for $\beta_{SMB}$ and $\beta_{HML}$, lower for $\beta_{MKT}$. Second, the lagged values of the proxies, not their recent changes are at the source of this explanatory power. This is seen clearly by comparing the R-squares of the full regression in (5) with $\bar{R}^2_{-1}$ reported below, to the R-square of a regression without $\Delta X$. The coefficient estimates for the change variables $\Delta X$ confirm this result. They are insignificant, and about half of the time of the correct sign, as expected under the null hypothesis. The only possible exception is $\Delta Div$, with the expected sign about two thirds of the time and a significant t-statistic.

In Table 4, subscripts $_{-1}$ refer to the estimates of $\delta$ in (5). The validity of each proxy individually can also be verified. We expect positive coefficients for Capx and Mb, negative for Div and Ep. Capital expenditures and dividends are significant and with the correct sign about every single period. The coefficient of $\text{Dtoe}_{-1}$ is significant and with the correct sign two-thirds of the time. This shows that one can recover the sign expected by the financial leverage hypothesis, once growth proxies have been accounted for. We note only two exceptions. For $\beta_{EW}$, the slope estimate for $\text{Mb}_{-1}$ is small, 0.002, insignificant, and with the correct sign half the time. The coefficient of $\text{Ep}_{-1}$ for $\beta_{VW}$ has a similar pattern.

We also ran a pooled cross-sectional / times series implementation of (5), where $\delta_t \equiv \delta$ and $\gamma_t \equiv \gamma$. It used 30 non-overlapping three-year periods for a total of 1000 observations.[12] Although, imposing the constancy of the relationship in (5) appears to be a formidable constraint, the results were very impressive. For $\beta_{EW}$, the R-square was still 45%, down from an average of 66%. For $\beta_{VW}$, the R-square was 27% down from an average of 54%.

To summarize, the lagged proxies explain a large fraction, up to two thirds, of cross-sectional differences in systematic risk. The relationship between betas and each proxy most often has the desired sign given that growth options have higher betas. Recent changes in the proxies do not have marginal explanatory power over and above the lagged values of the proxies, which is consistent a slow variation of true betas. The results are robust to methodological variations such as the use of

[12] This eliminated the autocorrelation in the residuals. A feasible GLS was used to allow for contemporaneously cross-correlated errors. To constrain the the 1000x1000 correlation matrix, we modelled equal cross-correlations, estimated from first step OLS residuals.

non-standardized proxies, or medians instead of means.

### 4.5 Return predictability and changes in growth options

Tables 1 and 2 showed that loser betas decline and winner betas increase. These patterns, which arise because of losses (or gains) in growth options, could induce predictability in extreme portfolio returns if investors are slow to account for the implication of growth options on betas. Consider the following three-period scenario for a loser stock. In period one, the stock incurs negative returns. If investors anchor their beliefs on large negative stock return, the financial leverage effect and ignore potential losses in growth options, they might believe that the equity beta is higher than it really is. Assume that the market excess return is positive in period 2. If investors have not yet accounted for the loser's decreased growth options, the loser stock rises according to the *"older"* beta that is too high. In period 3, investors adjust to the new, lower beta, correcting for the excessive rise of period 2. If this is the case, we expect to see a negative relationship between the excess return in period 3 and the market return in period 2. For winners, a similar reasoning could produce a positive relationship between the winner and the lagged market returns.

To examine this, we analyze the relationship between extreme portfolio returns and the previous year market excess returns. Specifically, we allocate firms to deciles portfolios according to their previous three-year returns, labelled months -35 to 0. We then compute the value weighted monthly returns of these portfolios over months 13 to 24 in excess of the risk free rate, $r_{p,t}$. Repeating this every year, results in a time series of monthly returns for these portfolios from January 69 to December 99. We regress $r_{p,t}$ on $r_{m,t-1}$ and $r_{m,t}$ the value-weighted market excess returns for the current and previous year, $r_{m,t-1}$. Namely, we run the regression,

$$r_{p,t} = \alpha_{0,p} + \beta_p * r_{m,t} + \beta_{1,p} * r_{m,t-1} + \epsilon_{p,t},$$

on annual returns. The results are in Table 5. For the losers, the estimate of $\beta_{1,p}$ is -0.44 with a t-statistic of -2.68. For the winners, the estimate of 0.12 has a t-statistic of 0.66. The last column shows that the difference between the two coefficients is large, -0.56, and significant -1.99.[13]

To summarize, we show that there is some evidence consistent with a scenario in which it takes more than a year for the market to fully incorporate changes in betas for the losers. There is no such evidence for the winners.

## 5 Conclusions

The determinants of univariate market betas was a relatively hot research topic in the 1970s and early 1980s but has recently attracted much less attention. This is somewhat surprising given that the prevailing view on what determines changes in betas, based on the Rubinstein and Hamada leverage arguments, seems to be at odds with the evidence. In particular, as we emphasize in this paper, the betas of stocks that have experienced very high returns do not decline as the leverage theory suggests, and the betas of stocks that have experienced negative returns decline significantly, which is inconsistent with that theory.

Our analysis suggests that this puzzle can at least partially be explained by the relation between past stock returns and changes in a firm's mix between growth options, which generally have high betas, and assets in place, which generally have low betas. Similar analysis might also be applied to a second related puzzle. Firms that take actions that increase financial leverage tend to experience decreases, rather than increases, in their market betas.[14] Moreover, the equity betas of financially distressed firms seem to decline as their financial condition deteriorates even though the unsystematic risk and total risk increase.[15] While this evidence is inconsistent with the Hamada and Rubinstein leverage adjustments, it is consistent with the idea that firms increase (decrease)

[13]Statistical power can, in principle, be increased by using overlapping (monthly) observations. We ran the regression on 349 monthly observations, correcting the OLS standard errors to allow for 12 months of linearly declining autocorrelation in the residuals. The results, not reported here, were similar.

[14]Healy and Palepu (1990) and Lease, Masulis and Page (1993) find that share offerings are followed by increases in equity beta. Bartov (1991), Hertzel and Jain (1991), and Dann, Masulis, and Mayers (1991) find that share repurchases are followed by decreases in beta. However, Denis and Kadlec (1994), after correcting for potential biases due to infrequent trading and price adjustment delays, find no evidence of changes in beta after equity offerings or share repurchases. Finally, Kaplan and Stein (1990) find that equity betas do increase after leveraged recapitalizations that substantially increase leverage, but much less than predicted by the Hamada model.

[15]See, for example, Aharony, Jones, and Swary (1980), Altman and Brenner (1981), and McEnally and Todd (1993). They attribute the decline in betas to possible decreases in the systematic risk of earnings, but do not explain why this may be the case.

leverage when the value of their growth options decline (increase).[16]

We conjecture that we are most likely to see evidence of the Hamada/Rubinstein leverage effect by analyzing the stocks of highly levered firms that subsequently experience very negative returns. The high leverage of these firms should increase the importance of the leverage effect, and since these firms tend to have very few growth options, the offsetting effect should be minimized. However, we find that even for these firms, the betas of past losers tend to decrease.

Finally, we consider the possibility that investors fail to appreciate these beta changes, which would imply that past winners and losers would either over or underreact to market moves. We present preliminary results that suggest that the losers tend to have betas that are too high, implying that they overreact to market returns. This finding will be the subject of future research.

**APPENDIX: Partial derivative of $\eta_G = \frac{\beta_G}{\beta_S}$ with respect to the moneyness ratio.**

Consider $N(d_1), N(d_2), r_f, T$ as in the standard Black-Scholes notation. Denote $S$ the underlying value, $C$ the strike price, and $m = S/C$ the moneyness ratio. The elasticity of the option $G$ with respect to the underlying $S$ is

$$\eta_G = \frac{SN(d_1)}{G} = \frac{SN(d_1)}{SN(d_1) - Ce^{-r_f T}N(d_2)} = \left[1 - \frac{1}{m}e^{-r_f T}\frac{N(d_2)}{N(d_1)}\right]^{-1} \geq 1.$$

The partial derivative of $\eta_G$ with respect to the moneyness ratio $m$ is

$$\begin{aligned}\frac{\partial \eta_G}{\partial m} &= e^{-r_f T}\,\eta_S^2\,\frac{\partial\left(\frac{N(d_2)}{mN(d_1)}\right)}{\partial m} \\ &= e^{-r_f T}\,\eta_S^2\,\left[-\frac{N(d_2)}{m^2N(d_1)} + \frac{1}{mN^2(d_1)}(N(d_1)Z(d_2)\frac{\partial d_2}{\partial m} - N(d_2)Z(d_1)\frac{\partial d_1}{\partial m})\right], \qquad (6)\end{aligned}$$

where Z(·) is the standard normal density function, $d_1 = \frac{ln(m)+(r_f+0.5\sigma^2)T}{\sigma\sqrt{T}}$, and $d_2 = d_1 - \sigma\sqrt{T}$.

Note that $\frac{\partial d_1}{\partial m} = \frac{\partial d_2}{\partial m} = \frac{1}{m\sigma\sqrt{T}}$, recall that $\eta_G = SN(d_1)/G$, and replace $m$ with $\frac{S}{C}$. Equation (6) simplifies as

$$\frac{\partial \eta_G}{\partial m} = -\frac{C^2e^{-r_f T}}{S^2\sigma\sqrt{T}}N(d_2)N(d_1)\left(\sigma\sqrt{T} - \frac{Z(d_2)}{N(d_2)} + \frac{Z(d_1)}{N(d_1)}\right).$$

Galai and Masulis (1976, p. 76-77) show that $\sigma\sqrt{T} > \frac{Z(d_2)}{N(d_2)} - \frac{Z(d_1)}{N(d_1)}$. Hence, $\frac{\partial \eta_G}{\partial m}$ is negative.

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[16] Lease et al. (1993) also show that operating leverage increases after equity offerings. They note that the increases in equity betas and operating leverage following equity offerings are consistent with increased risk in the issuing firm's assets.

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**Table 1: Betas before and after ranking**

Firms are allocated to 10 groups ranked by total return for (27) three-year periods from 1968-70 to 1994-96. Panel A reports the average of the cumulative returns (first three columns), debt to equity ratios (Dtoe) and betas with respect to the equal and value weighted CRSP indices and the three Fama-French factors, $\beta_{EW}, \beta_{VW}, \beta_{MKT}, \beta_{HML}, \beta_{SMB}$, for each group. The column headers 0, -1, and 1, refer to the ranking period, and the two three-year periods preceding (65-67 to 89-91) and following (71-73 to 97-99) the ranking period. Panel B shows some of these statistics for low and high leverage (Dtoe) firms. Firms are grouped in Dtoe deciles in period -1. Within each leverage group, firms are then allocated to cumulative returns deciles in period 0.

**Panel A: Sorting by cumulative return from losers to winners in period 0**

| | Ret. in % | | | $\beta_{EW}$ | | | $\beta_{VW}$ | | | $\beta_{MKT}$ | | | $\beta_{HML}$ | | | $\beta_{SMB}$ | | | Dtoe % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 |
| L | 75 | -53 | 68 | 1.13 | 0.96 | 1.11 | 1.29 | 1.03 | 1.03 | 1.05 | 0.91 | 0.97 | -0.01 | 0.22 | 0.47 | 1.02 | 0.91 | 1.19 | 53 | 147 | 119 |
| 2 | 61 | -8 | 58 | 0.99 | 0.87 | 0.92 | 1.16 | 0.99 | 0.96 | 0.99 | 0.90 | 0.94 | 0.04 | 0.20 | 0.40 | 0.78 | 0.74 | 0.85 | 58 | 93 | 84 |
| 3 | 57 | 13 | 53 | 0.94 | 0.84 | 0.84 | 1.13 | 0.99 | 0.92 | 0.98 | 0.91 | 0.90 | 0.09 | 0.19 | 0.33 | 0.69 | 0.65 | 0.70 | 60 | 80 | 80 |
| 4 | 54 | 29 | 51 | 0.90 | 0.81 | 0.79 | 1.08 | 0.97 | 0.91 | 0.95 | 0.90 | 0.90 | 0.13 | 0.20 | 0.28 | 0.65 | 0.58 | 0.59 | 64 | 73 | 75 |
| 5/6 | 50 | 48 | 52 | 0.88 | 0.82 | 0.79 | 1.06 | 0.99 | 0.93 | 0.94 | 0.91 | 0.90 | 0.16 | 0.20 | 0.20 | 0.64 | 0.58 | 0.53 | 68 | 65 | 67 |
| 7 | 50 | 70 | 49 | 0.93 | 0.91 | 0.84 | 1.09 | 1.07 | 0.98 | 0.96 | 0.96 | 0.92 | 0.22 | 0.17 | 0.14 | 0.73 | 0.68 | 0.57 | 74 | 57 | 65 |
| 8 | 53 | 89 | 53 | 0.97 | 0.98 | 0.90 | 1.12 | 1.13 | 1.04 | 0.97 | 1.00 | 0.95 | 0.16 | 0.12 | 0.03 | 0.82 | 0.76 | 0.63 | 71 | 49 | 56 |
| 9 | 53 | 116 | 48 | 1.04 | 1.10 | 1.00 | 1.18 | 1.24 | 1.14 | 1.01 | 1.08 | 1.02 | 0.19 | 0.11 | -0.01 | 0.99 | 0.92 | 0.71 | 81 | 43 | 57 |
| W | 42 | 184 | 42 | 1.14 | 1.34 | 1.12 | 1.19 | 1.42 | 1.23 | 0.96 | 1.20 | 1.04 | 0.20 | 0.11 | -0.18 | 1.30 | 1.27 | 0.88 | 107 | 36 | 53 |

**Panel B: Losers and winners in period 0 with extreme leverage in period -1**

| Group | | Ret. in % | | | $\beta_{EW}$ | | | $\beta_{VW}$ | | | $\beta_{HML}$ | | | Dtoe % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dtoe | Return | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 |
| Low: 1 | L: 1 | 89 | -63 | 68 | 1.15 | 0.95 | 1.14 | 1.30 | 1.01 | 0.99 | -0.32 | 0.12 | 0.46 | 0 | 25 | 26 |
| Low: 1 | W: 10 | 60 | 178 | 40 | 1.10 | 1.27 | 1.13 | 1.18 | 1.30 | 1.23 | -0.07 | 0.05 | -0.29 | 0 | 5 | 13 |
| 9 | 1 | 39 | -42 | 75 | 1.05 | 0.92 | 1.02 | 1.15 | 0.92 | 0.99 | 0.27 | 0.49 | 0.61 | 138 | 264 | 193 |
| 9 | 2 | 39 | 0 | 61 | 0.88 | 0.74 | 0.84 | 1.02 | 0.83 | 0.90 | 0.37 | 0.36 | 0.53 | 139 | 180 | 161 |
| High: 10 | L: 1 | 23 | -37 | 92 | 1.09 | 0.96 | 1.09 | 1.18 | 0.97 | 1.03 | 0.44 | 0.55 | 0.65 | 276 | 578 | 272 |
| High: 10 | W: 10 | -4 | 217 | 48 | 1.12 | 1.53 | 1.08 | 1.09 | 1.50 | 1.13 | 0.43 | 0.54 | 0.09 | 386 | 94 | 96 |

**Table 2: Winners and losers sorting by risk-adjusted excess-return**
Table 2 reports $\beta$'s and cumulative total returns of 10 deciles of firms in the ranking and pre- and post-ranking periods. In the ranking period, column header 0, firms are allocated to deciles according to their $\alpha$ in the excess-return market model regression in section II. The market index used in the regression is the value weighted CRSP for column $\beta_{VW}$ and the equal-weighted CRSP for column $\beta_{EW}$. For each decile and period, the values reported are averages over the firms in this decile and the 27 periods.

| | Ret. in % | | | $\beta_{EW}$ | | | $\beta_{VW}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| Decile | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 |
| L: 1 | 78 | -49 | 68 | 1.22 | 1.21 | 1.20 | 1.35 | 1.24 | 1.09 |
| 2 | 63 | -6 | 58 | 1.06 | 1.02 | 1.00 | 1.21 | 1.10 | 1.00 |
| 3 | 56 | 14 | 52 | 1.00 | 0.93 | 0.90 | 1.16 | 1.06 | 0.95 |
| 4 | 53 | 29 | 54 | 0.94 | 0.88 | 0.84 | 1.10 | 1.03 | 0.94 |
| 5 | 49 | 42 | 52 | 0.88 | 0.84 | 0.78 | 1.06 | 0.99 | 0.92 |
| 6 | 51 | 55 | 50 | 0.86 | 0.81 | 0.77 | 1.06 | 0.99 | 0.93 |
| 7 | 51 | 69 | 50 | 0.85 | 0.81 | 0.77 | 1.05 | 0.99 | 0.95 |
| 8 | 51 | 88 | 49 | 0.89 | 0.85 | 0.82 | 1.09 | 1.05 | 1.00 |
| 9 | 51 | 114 | 49 | 0.99 | 0.96 | 0.93 | 1.12 | 1.11 | 1.10 |
| W: 10 | 42 | 181 | 42 | 1.09 | 1.13 | 1.08 | 1.15 | 1.23 | 1.19 |

**Table 3: Betas versus growth proxies**

Every three years, firms are allocated to increasing growth opportunity deciles, 1 to 10, on the basis of increasing market to book value of assets (Mb) and ratio of capital expenditures to net fixed assets (Capx), and decreasing ratio of earnings to price (Ep) and dividend yield (Div). The table reports averages of proxy value, three-year returns (%R), $\beta$'s, and debt to equity ratios (dtoe) over 30 overlapping 3-year ranking periods, 65-67 to 94-96. Middle deciles are aggregated for brevity. In Panel C, the 38% of firms with 0 dividend are assigned to the High Growth group 10 and the other firms are assigned to the other 9 groups. In Panel D, the 15% of firms with non-positive Ep are also in group 10.

| | Proxy | % R | $\boldsymbol{\beta}_{EW}$ | $\boldsymbol{\beta}_{VW}$ | Dtoe | $\boldsymbol{\beta}_{MKT}$ | $\boldsymbol{\beta}_{HML}$ | $\boldsymbol{\beta}_{SMB}$ |
|---|---|---|---|---|---|---|---|---|
| A: Growth proxy is increasing % Capx | | | | | | | | |
| Low | 5 | 30 | 0.91 | 0.95 | 1.28 | 0.86 | 0.46 | 0.91 |
| 2 | 10 | 36 | 0.85 | 0.96 | 1.00 | 0.88 | 0.37 | 0.75 |
| 3 | 13 | 41 | 0.89 | 1.01 | 0.92 | 0.91 | 0.29 | 0.78 |
| 4/5/6 | 19 | 48 | 0.93 | 1.09 | 0.64 | 0.96 | 0.17 | 0.77 |
| 7/8 | 27 | 60 | 1.03 | 1.18 | 0.52 | 1.02 | 0.04 | 0.87 |
| 9 | 38 | 74 | 1.15 | 1.29 | 0.46 | 1.06 | -0.05 | 1.04 |
| High 10 | 64 | 92 | 1.28 | 1.38 | 0.45 | 1.08 | -0.19 | 1.25 |
| B: Growth proxy is increasing Mb | | | | | | | | |
| Low | 0.74 | 10 | 0.96 | 0.94 | 1.02 | 0.82 | 0.49 | 1.10 |
| 2 | 0.89 | 21 | 0.98 | 1.03 | 1.37 | 0.90 | 0.41 | 1.04 |
| 3 | 0.97 | 33 | 0.93 | 1.04 | 1.25 | 0.92 | 0.35 | 0.85 |
| 4/5/6 | 1.14 | 47 | 0.93 | 1.07 | 0.84 | 0.95 | 0.24 | 0.78 |
| 7/8 | 1.51 | 68 | 1.03 | 1.20 | 0.36 | 1.02 | 0.03 | 0.85 |
| 9 | 2.07 | 87 | 1.07 | 1.26 | 0.14 | 1.05 | -0.20 | 0.83 |
| High | 4.21 | 110 | 1.16 | 1.35 | 0.05 | 1.11 | -0.36 | 0.91 |
| C: Growth proxy is decreasing % Div | | | | | | | | |
| Low | 10.2 | 29 | 0.49 | 0.65 | 1.31 | 0.69 | 0.49 | 0.18 |
| 2 | 6.1 | 33 | 0.67 | 0.85 | 0.83 | 0.81 | 0.36 | 0.43 |
| 3 | 4.8 | 38 | 0.79 | 0.97 | 0.68 | 0.89 | 0.28 | 0.57 |
| 4/5/6 | 3.3 | 51 | 0.87 | 1.08 | 0.54 | 0.96 | 0.17 | 0.62 |
| 7/8 | 1.8 | 68 | 0.95 | 1.17 | 0.47 | 1.01 | 0.01 | 0.73 |
| 9 | 0.7 | 91 | 1.05 | 1.31 | 0.37 | 1.10 | -0.15 | 0.81 |
| High | 0.0 | 55 | 1.25 | 1.25 | 0.82 | 1.03 | 0.12 | 1.34 |
| D: Growth proxy is decreasing % Ep | | | | | | | | |
| Low | 20 | 65 | 0.97 | 1.04 | 1.14 | 0.91 | 0.40 | 0.97 |
| 2 | 13 | 59 | 0.88 | 1.01 | 0.80 | 0.90 | 0.32 | 0.77 |
| 3 | 11 | 57 | 0.86 | 1.01 | 0.68 | 0.90 | 0.25 | 0.71 |
| 4/5/6 | 9 | 58 | 0.92 | 1.10 | 0.55 | 0.97 | 0.10 | 0.71 |
| 7/8 | 7 | 68 | 1.02 | 1.22 | 0.41 | 1.03 | -0.05 | 0.81 |
| 9 | 2 | 62 | 1.11 | 1.25 | 0.55 | 1.04 | 0.00 | 1.03 |
| High | -25 | 11 | 1.19 | 1.13 | 1.16 | 0.99 | 0.24 | 1.31 |

**Table 4: Cross-sectional variations in betas**

For each (of 30) 3-year overlapping ranking period from 65-67 to 94-96, we allocate firms to 100 portfolios sorted by cumulative returns. For each portfolios, we compute growth proxies as the median of thoses of the firms in the portfolio for this ranking period, and the average $\beta$'s for the following 3-year period. The proxies are Mb, Ep, Capx, Dtoe, and Div. The dummy variable $d_{Div}$ is 1 when Div=0. We regress portfolio $\beta$'s on lagged growth proxies ($_{-1}$) and changes ($\Delta$). For each of the 30 regressions, proxies and changes in proxies are standardized across the 100 observations. $Q_1$ and $Q_3$ are the first and third quartile of the 30 point estimates. # is the number of estimates with the expected sign. $t$, the t-statistic on the average of the 30 estimates, accounts for three lags of autocorrelation. $\bar{R}^2$ and $\bar{R}^2_{-1}$ report on the adjusted R-squares of the regressions, with all the independent variables and that with only the lagged ($_{-1}$) variables.

**Panel A: Dependent variables, $\boldsymbol{\beta}_{EW}$, $\boldsymbol{\beta}_{VW}$**

| | $\beta_{EW}$ | | | | | $\beta_{VW}$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | $Q_1$ | $Q_3$ | # | t | Mean | $Q_1$ | $Q_3$ | # | t |
| $Capx_{-1}$ | 0.029 | 0.007 | 0.043 | 25 | 5.5 | 0.037 | 0.013 | 0.060 | 26 | 6.1 |
| $d_{Div}$ | 0.196 | 0.116 | 0.257 | 30 | 8.2 | 0.148 | 0.043 | 0.230 | 28 | 4.8 |
| $(1-d)Div_{-1}$ | -0.086 | -0.108 | -0.063 | 30 | -11.6 | -0.076 | -0.108 | -0.047 | 27 | -7.0 |
| $Mb_{-1}$ | 0.002 | -0.030 | 0.039 | 15 | 0.2 | 0.035 | 0.013 | 0.076 | 25 | 2.7 |
| $Ep_{-1}$ | -0.053 | -0.075 | -0.002 | 23 | -3.3 | -0.013 | -0.048 | 0.018 | 17 | -1.1 |
| $Dtoe_{-1}$ | 0.020 | -0.003 | 0.049 | 21 | 2.6 | 0.016 | -0.005 | 0.035 | 20 | 1.9 |
| $\Delta$Capx | 0.005 | -0.008 | 0.016 | 17 | 1.2 | 0.007 | -0.008 | 0.021 | 18 | 1.4 |
| $\Delta$Div | -0.012 | -0.023 | 0.001 | 21 | -2.9 | -0.010 | -0.020 | -0.001 | 23 | -2.3 |
| $\Delta$Mb | -0.019 | -0.046 | 0.007 | 11 | -2.5 | -0.005 | -0.019 | 0.018 | 14 | -0.6 |
| $\Delta$Ep | -0.007 | -0.033 | 0.021 | 14 | -0.6 | 0.000 | -0.034 | 0.029 | 11 | -0.0 |
| $\Delta$Dtoe | -0.004 | -0.015 | 0.017 | 17 | -0.5 | -0.005 | -0.013 | 0.011 | 16 | -0.6 |
| $\bar{R}^2$% | 66 | 62 | 75 | | | 54 | 39 | 66 | | |
| $\bar{R}^2_{-1}$% | 64 | 59 | 74 | | | 52 | 41 | 65 | | |

**Panel B: Dependent variables, $\boldsymbol{\beta}_{MKT}$, $\boldsymbol{\beta}_{HML}$, $\boldsymbol{\beta}_{SMB}$**

| | $\beta_{MKT}$ | | | $\beta_{HML}$ | | | $\beta_{SMB}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Q1 | Q3 | Mean | Q1 | Q3 | Mean | Q1 | Q3 |
| $\bar{R}^2$% | 26 | 16 | 33 | 42 | 32 | 55 | 52 | 40 | 65 |
| $\bar{R}^2_{-1}$% | 25 | 14 | 33 | 41 | 30 | 53 | 49 | 37 | 62 |

**Table 5: Predictability in extreme portfolio returns**

Panel A shows the correlation between the annual excess return of the market index $r_{m,t-1}$ and three decile portfolios, 1, 5, and 10, $r_{p,t}$ where $t$ is a year. Every year, firms are allocated to 10 deciles on the basis of their total returns over the previous three years, months -35 to 0. Decile 1 and 10 are the losers and winners. Returns on these portfolios are then computed over months 13 to 24, labelled as year $t$. Returns are market value weighted returns of the firms in the decile, using market value at the beginning of each month. The market return is collected during months 1 to 12, year $t-1$. We run the regression:

$$r_{p,t} = \alpha_{0,p} + \beta_p * r_{m,t} + \beta_{1,p} * r_{m,t-1} + \epsilon_{p,t},$$

using thirty non-overlapping annual observations.

| | Loser | Middle | Winner | Loser-Winner |
|---|---|---|---|---|
| $\alpha_{0,p}$ | 0.03 | 0.02 | -0.04 | 0.07 |
| | (1.03) | (1.10) | (-1.08) | (1.30) |
| $\beta_p$ | 1.04 | 0.95 | 1.28 | -0.24 |
| | (6.40) | (11.7) | (7.17) | (-0.88) |
| $\beta_{1,p}$ | -0.44 | 0.02 | 0.12 | -0.56 |
| | (-2.68) | (0.18) | (0.66) | (-1.99) |
| $\bar{R}^2$ | 0.63 | 0.82 | 0.63 | 0.08 |

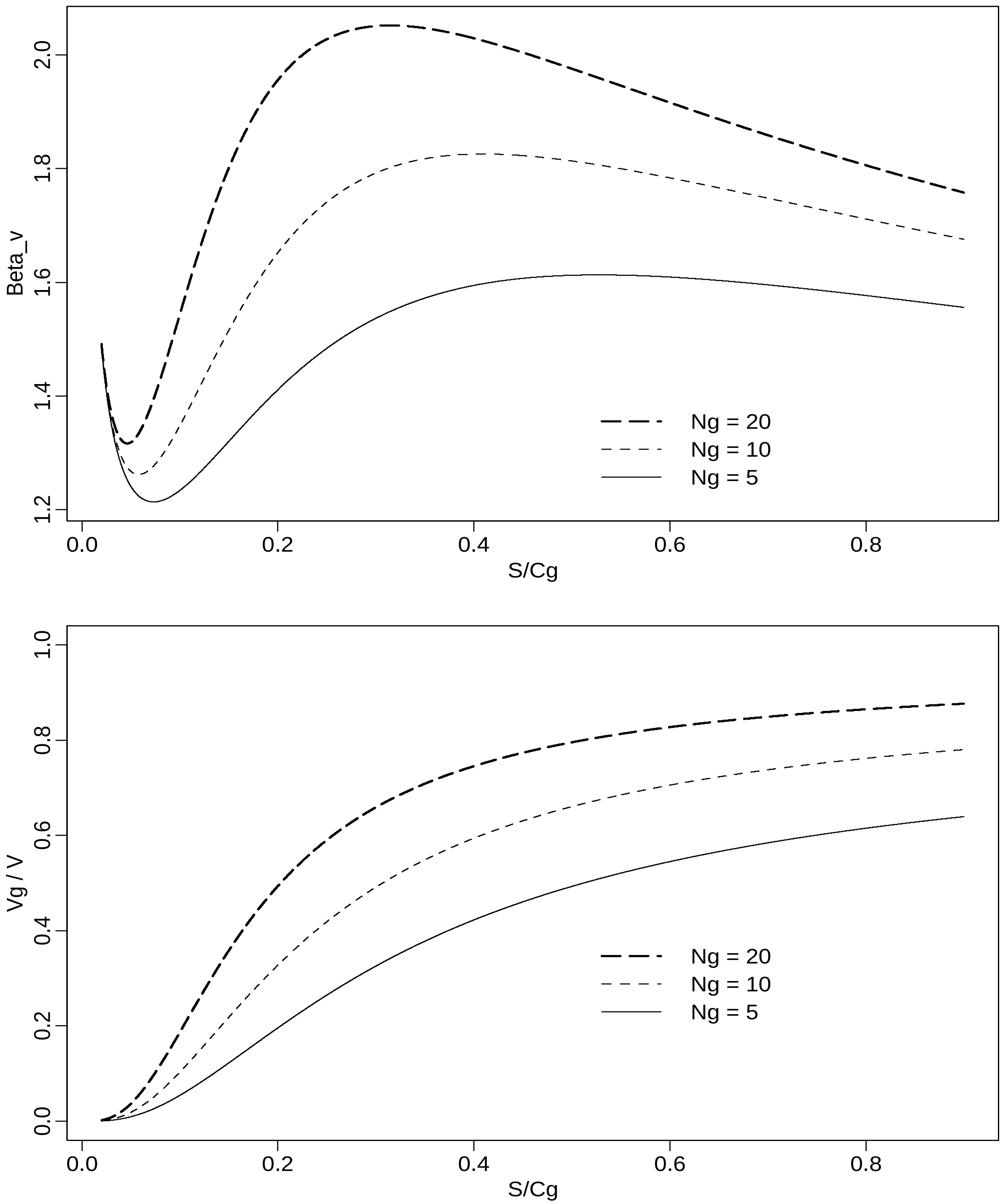


**Figure 1:** Firm $\beta$ and weight in growth options versus moneyness

The top panel plots $\beta_V = (AN_A\beta_A + GN_G\beta_G)/V$ vs $s/C_G$, where $V = AN_A + GN_G = V_A + V_G$. $A$ and $G$ are calls on $s$ with exercise prices $C_A = 1, C_G = 100$. $r_f = 0, \sigma^2 T = 1$. $N_A = 1$ and $N_G = 5, 10, 20$. The bottom panel plots the weight in growth options $V_G/V$ vs moneyness $s/C_G$.