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Global Evidence on Growth Opportunities, Beta, and the Cost of Capital

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Abstract This study investigates the influence of firms' growth opportunities on their cost of capital across industries using an international sample of 28 developed and 22 emerging markets. Our results based on more than 21,000 firms and 167,000 firm-years corroborate that a high magnitude of firms' growth opportunities leads to a higher firms' unlevered beta. Moreover, we establish that for the majority of sectors in our global sample, the beta of growth opportunities is greater than the beta of assets-in-place. Failure to account for growth opportunities can underestimate the cost of equity by up to 3 percentage points, depending on the industry.

Keywords Growth Options, Assets-in-Place, Beta, Cost of Capital

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1. Introduction

The concept of a company's cost of capital is vital for capital budgeting. The cost of capital is employed to discount expected future cash flows of a proposed investment project subject to evaluation for acceptance or rejection. The cost of capital is typically estimated with the classical capital asset pricing model (CAPM) established in the 1960s by Treynor (1961, 1962), Sharpe (1964), Lintner (1965), and Mossin (1966). There is often a considerable disagreement about what a reasonable amount of systematic risk (measured by beta) is for a proposed investment. Myers and Turnbull (1977) have long recognized a need to regard future investments as growth opportunities and account for their value as a real option, which consequently leads to a higher firm's beta. This point was later confirmed by Chung and Charoenwong (1991), Berk et al. (1999, 2004), and Jacquier et al. (2010). This state of the research opens up a challenging discussion regarding reliable empirical evidence for the systematic impact of growth opportunities on firms' beta and for measuring its extent to provide useful suggestions for the calculation of cost of capital.

Empirical results of previous research indicate that the value of growth opportunities is an essential component of corporate value. It accounts for a higher proportion of the market value of firms than of the value of their assets in place (see, for instance, Kester (1986), Pindyck (1988), and Danbolt et al. (2002)). Kester (1984) has even found that the proportion of growth opportunities is up to 80 percent of the market value of companies with strong fluctuations in demand. Danbolt et al. (2002) emphasize, however, that the methods for evaluating growth opportunities applied by various studies do not provide a stringent link to real options, which was suggested by Myers and Turnbull (1977).

Bernardo et al. (2007) demonstrate empirically for the U.S. market not only that growth opportunities are an integral part of a firm's beta but also argue that the distribution of firms' betas across industries depends on their growth opportunities, which leads to a better estimation of the corporate cost of capital. Bernardo et al. (2012) illustrate further how to apply this approach to capital budgeting.

We are the first to reexamine this effect of growth opportunities on firms' cost of capital. We analyze this research question worldwide, utilizing a comprehensive sample of 28 developed and 22 emerging markets from 1980 to 2008.

In sum, we provide out-of-sample support for the connection between growth opportunities of firms and their unlevered beta within an industry. Our findings can be summarized as follows. First, firms with above-average growth opportunities exhibit a higher amount of unlevered betas than those with below-average growth opportunities. Motivated by theory, this empirical fact implies that when evaluating investment projects, one should consider whether this project has relatively more or less growth opportunities when choosing an adequate discount rate, e.g., by deriving the project beta from a peer-group benchmark. Second, we dissect the firm's unlevered beta in the beta of growth opportunities and the beta of assets-in-place, and provide empirical evidence, that the amount of beta of growth opportunities is significantly higher for the majority of industries in a global sample. Hence, the systematic risk of the firm's future investments is higher than that of its usual business activity. That means that a firm's cost of capital based on its firm beta may not be the best choice for evaluating its future investments. Consequently, to avoid overvaluation of growth companies or startup firms investors should rather apply the beta of growth opportunities as the relevant risk measure. In contrast, the beta of assets-in-place is more plausible for well-established firms.

The rest of the paper proceeds as follows. Section 2 discusses the theoretical link between growth options and systematic risk. Section 3 describes the data and explains the methodology for estimating the impact of growth options on a firm's beta. Section 4 presents and interprets the results while checking their robustness. Section 5 concludes.

2. Contingent Claims Valuation of Growth Opportunities and its Link to Systematic Risk

This section provides the theoretical link between growth options and beta, highlighting that the beta of growth opportunities is greater than the beta of assets-in-place. To show this, we resort to the methodological explanations by Carlson et al. (2004, 2006) and Bernardo et al. (2007).

It is helpful to think of firms as having assets-in-place and investment projects with a growth option component. In line with Miller and Modigliani (1961), Bernardo et al. (2007), and Jacquier et al. (2010), the firm value V_t at time *t* is composed as the sum of two parts

$$V_t = A_t + G_t , \qquad (1)$$

where A_t is the portion of a firm's value that is accounted for by assets already in place and G_t is the value of a firm's growth opportunities at time t.

Assuming that firms execute gradually their growth opportunities to a certain extent, the cash flow positions for investment I_t increase. Consequently, the growth option on firm's asset-in-place fluctuates randomly. It can therefore be assumed that A_t follows a geometric Brownian motion:

$$\frac{dA_t}{A_t} = \mu dt + \sigma dw_t , \qquad (2)$$

where μ is the continuously compounded rate of return of assets-in-place that is perfectly correlated with A_t, σ is the instantaneous standard deviation of μ, and dw_t is a Wiener process (see McDonald and Siegel (1986)). The proportional change in the asset value (i.e., $\frac{dA_t}{A_t}$) consists of the deterministic drift μ and a random shock driven by dw_t.

Numerous studies assume that the asset value's growth rate $\frac{dA_t}{A_t}$ is equal to the rate of return μ only in the case of financial assets (see Miles (1986)). We assume that the aforementioned investment I_t can be harvested between now t and the future $t+T$, and that stochastic changes in A_t are spanned by existing assets. Assuming a frictionless market the value of the growth opportunity at time t can then be determined with the Black and Scholes (1973) equation for a call option (European and American)

$$G_t = A_t N(d_1) - I_t e^{-rT} N(d_2) , \qquad (3)$$

where $d_1 = \frac{\ln\left(A_t / I_t\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}, \; d_2 = d_1 - \sigma\sqrt{T}$,

$N(.)$ is the cumulative distribution function of the standard normal distribution, and r is the instantaneous risk-free rate.

To show the relationship between the CAPM measure of risk, beta, and this option pricing model, it is essential to mention that the CAPM can also exist in continuous time because the Black-Scholes model requires continuous trading.[1] The assumptions underlying the two models should be consistent. Following this assessment, we show in Appendix A that

[1] Merton (1973) derives a continuous-time version of the CAPM.

$$\beta^G = \frac{\frac{dG}{dA}}{\frac{G}{A}} \beta^A \quad . \qquad (4)$$

It is straightforward to show that

$$\frac{dG_t}{dA_t} = N(d_1), \text{ where } 0 \leq N(d_1) \leq 1.$$

Inserting this relation into (4) leads to

$$\beta_t^G = \frac{N(d_1)A_t}{G_t} \beta_t^A \quad . \qquad (5)$$

As shown in Appendix B, the inequality $\frac{N(d_1)A_t}{G_t}$ usually exceeds one, resulting in $\beta_t^G > \beta_t^A$.

The economic intuition behind this insight is that the growth opportunity of a company represents an option on its assets-in-place. As this option to invest has an implicit leverage component, the beta of growth opportunity is larger than the beta of assets-in-place. (e.g., Berk et al. (1999, 2004), Carlson et al. (2004, 2006)).

However, betas are closely linked to expected returns (see Campbell and Mei (1993)). Lettau and Wachter (2007), and Santos and Veronesi (2010) emphasize that expected returns of growth companies holding assets characterized by a long duration are more sensitive to interest rate fluctuations than expected returns of value stocks, which vary more to changes in cash flows. Hence, firms with a considerable amount of growth opportunities should exhibit higher growth betas.

Whatever the story, the focus of this paper is to test out-of-sample the theoretically based hypothesis $\beta_t^G > \beta_t^A$ empirically by examining 50 developed and emerging countries. Our research has important implications for capital budgeting when estimating the cost of capital at the international level.

3. Estimation of the Effect of Growth Options on a Firm's Beta

3.1. Dataset

This section discusses data sources and the development of our dataset. We provide dominantly an out-of-sample analysis of Bernardo et al. (2007) who investigate a 1977-2004 U.S. sample over 28 years.

Monthly total returns for all companies listed between July 1980 and June 2008 (29 years) at the global level stem from DataStream International. The obtained returns include dividends. Relevant accounting data are sourced from World scope International for all countries. To manage the data with different currencies, we convert all data to U.S. dollars for better comparability.

Our sample selection procedure includes several measures. First, we include all delisted common stocks with the most representative share class until they no longer exist (e.g., Brown et al. (1992), Ince and Porter (2006)). At the same time, the data were controlled for preferred stocks, depositary receipts, warrants, unit and investment trusts. Second, cross-listed firms across all countries were excluded. Third, all monthly returns above 300% were not taken into account. Finally, to ensure that returns are driven only by liquid shares, all stocks quoted below one U.S. dollar (penny stocks) are excluded.

Table 1 provides summary statistics for each country included in the sample. The classification into developed and emerging markets follows the International Monetary Fund (IMF). It is important to note, that in contrast to developed markets with continuous availability of data since July 1980, data of most emerging markets is only available by the 1990s. The worldwide sample encompasses a total of 21,019 unique stocks and 167,084 firm-years, with 83% of the firms and 86% of the firm years being from developed markets. Japan leads the global sample firm-years weight with 24%, the United States follows with 21%, and the United Kingdom with 6%. In emerging markets, leading countries with respect to firm-years are Malaysia (4%) and India (3%). The remaining 41% of the sample stem from the other 45 national markets. This global sample has added power as it is about five times larger than the U.S. subsample.

Table 1: Number of Stocks and Firm Years: 1980-2008

This table reports summary statistics of 28 developed markets (Panel A) and 22 emerging markets (Panel B) according to the International Monetary Fund (IMF) classification sorted by region. The start year of returns (beginning in July) indicates a country's inclusion in the sample. The number of stocks counts the amount of unique firms having a return history of at least 12 months. The last two columns show the absolute number of firm years available for each country and a country's weight in the developed or emerging markets sample.

Panel A: Developed Markets

Country	Start Year of Returns	Number of Stocks	Firm Years	Portion	Country	Start Year of Returns	Number of Stocks	Firm Years	Portion
America					Europe				
Canada	1980	934	5,546	3.85%	Austria	1980	90	744	0.52%
USA	1980	4,475	35,904	24.96%	Belgium	1980	137	1,322	0.92%
Asia					Czech Republic	1996	35	179	0.12%
Hong Kong	1980	485	2,979	2.07%	Denmark	1980	173	1,566	1.09%
Israel	1992	98	747	0.52%	Finland	1989	131	828	0.58%
Japan	1980	3,528	40,645	28.25%	France	1980	709	5,462	3.80%
Singapore	1980	432	2,737	1.90%	Germany	1980	744	5,036	3.50%
South Korea	1987	656	4,323	3.00%	Greece	1990	278	1,878	1.31%
Taiwan	1990	666	4,675	3.25%	Ireland	1980	47	520	0.36%
Oceania					Italy	1980	290	2,689	1.87%
Australia	1980	888	4,632	3.22%	Luxembourg	1994	19	95	0.07%
New Zealand	1989	106	633	0.44%	Netherlands	1980	153	1,714	1.19%
					Norway	1980	188	1,425	0.99%
					Portugal	1990	58	519	0.36%
					Spain	1989	148	1,433	1.00%
					Sweden	1984	275	2,144	1.49%
					Switzerland	1980	249	2695	1.87%
					U.K.	1980	1,431	10,798	7.51%
Total Developed Markets							17,423	143,868	100.00%

Panel B: Emerging Markets

Country	Start Year of Returns	Number of Stocks	Firm Years	Portion	Country	Start Year of Returns	Number of Stocks	Firm Years	Portion
Africa					Europe				
Egypt	1998	42	207	0.89%	Estonia	2003	6	16	0.07%
Morocco	1997	21	107	0.46%	Hungary	1993	34	203	0.87%

South Africa	1980	264	1,960	8.44%	Poland	1993	196	856	3.69%
America					Russia	1998	52	203	0.87%
Argentina	1990	56	471	2.03%	Asia				
Brazil	1997	76	359	1.55%	China	1994	103	523	2.25%
Chile	1992	129	1,022	4.40%	India	1992	873	5,322	22.92%
Colombia	1994	22	154	0.66%	Malaysia	1982	857	6,198	26.70%
Mexico	1990	96	715	3.08%	Pakistan	1993	102	573	2.47%
Peru	1993	45	205	0.88%	Philippines	1990	55	343	1.48%
Venezuela	1992	23	175	0.75%	Sri Lanka	1993	30	240	1.03%
					Thailand	1989	314	1,887	8.13%
					Turkey	1990	200	1,477	6.36%
Total Emerging Markets							3,596	23,216	100.00%
Worldwide Sample							**21,019**	**167,084**	

We assign firms to sectors according to the Industry Classification Benchmark (ICB) legacy tapes launched by Dow Jones and FTSE to analyze the impact of growth opportunities on firms' unlevered beta across industries. Similar to Bernardo et al. (2007), who exclude 11 of the 48 Fama-French industries, we exclude Banks, Financial Services, Life Insurance, Nonequity Investment Instruments, Nonlife Insurance, Real Estate Investment and Services, REITs, and Tobacco. Fama and French (1992) justify the exclusion of financial firms due to their high levels of debt. Such levels would indicate financial distress for nonfinancial firms. This procedure leaves us with 32 from the 40 legacy ICB sectors.

3.2. Methodology

To measure the effect of growth opportunities on a firm's beta, we resort to the method applied by Bernardo et al. (2007). Based on equation (1) the value of firm i as:

$$V_{i,t} = A_{i,t} + G_{i,t} . \quad (6)$$

Furthermore, the firm's beta at time t (unlevered beta) $\beta_{i,t}$ can be represented as a weighted average of the beta of assets-in-place $\beta_{i,t}^{A}$ and of the beta of growth opportunities $\beta_{i,t}^{G}$

$$\beta_{i,t} = \frac{A_{i,t}}{V_{i,t}} \beta_{i,t}^{A} + \frac{G_{i,t}}{V_{i,t}} \beta_{i,t}^{G} . \quad (7)$$

Rewriting this equation as $\beta_{i,t} = \frac{A_{i,t}}{V_{i,t}} \beta_{i,t}^{A} + \left(1 - \frac{A_{i,t}}{V_{i,t}}\right) \beta_{i,t}^{G}$ and further simplifying leads to

$$\beta_{i,t} = \beta_{t}^{G} - \left(\beta_{t}^{G} - \beta_{t}^{A}\right) \frac{A_{i,t}}{V_{i,t}} \quad (8)$$

For the weights of firms' growth opportunities and assets-in-place we apply a well-recognized proxy variable, which correlates to changes of investment opportunities (see e.g., Goyal et al. (2002)). Furthermore, Adam and Goyal (2008) establish that the market-to-book ratio is the least noisy proxy variable.

Since the reciprocal of the market-to-book ratio is similar to the book value of assets-in-place to total firm value weight, a book-to-market weight BM is the corresponding proxy.[2] This is in line with the Bernardo et al. (2007) procedure computing the BM weight as book value of long-term outstanding debt and common equity over book value of debt and market value of shares of firm i at time t (D+E).

To disentangle a firm's unlevered beta into the beta of assets-in-place and the beta of growth opportunities, Bernardo et al. (2007) further assume that β_t^A and β_t^G apply to all firms within the same industry, but can vary over time. We follow their approach and are aware that variation within an industry might be due to different phases of the corporate life cycle (startup venture vs. well-established company).

We estimate the firm's equity beta annually using a market model with a 60-month rolling window. Based on our sample, we create capitalization-weighted country-specific indexes (total returns) to generate market returns. Due to the imperfect integration of financial markets as documented in Griffin (2002) and Fama and French (2012), we use country-specific market returns to ensure the quality of the beta estimation. Bernardo et al. (2007) use the Hamada (1972) equation to unlever the CAPM beta.

$$\beta_{i,t} = \frac{\beta_{i,t}^E}{1 + \left(1 - \tau_{k,t}\right)\frac{D_{i,t}}{E_{i,t}}} \quad (9)$$

They make the simplifying assumption of a uniform corporate tax rate of τ = 33% for the 1977-2004 U.S. sample. This is plausible given the statutory and effective rates over this period, with an apparent weight on statutory rates. Equation (9) is rooted in a fixed debt policy formulated by Modigliani and Miller (1963) for a non-growing perpetuity of debt interest payments with corporate taxes.

We differ from their approach in our global study for two reasons. First, Luehrman (1997), in summarizing the literature, states that the jury is still out on which debt policy (fixed vs. value-based) is prevalent. Miles and Ezzell (1980) have introduced the alternative notion of a value-based debt policy. Second, the tax rate $\tau_{k,t}$ is often time-varying across countries k as national tax codes change regularly. For our sample of 50 countries over almost 30 years, the availability of corporate tax rate data and each national tax code's proper implementation of statutory rates in the U.S. tax code-inspired equation (9) seems challenging.

However, based on the paper by Miles and Ezzell (1980), Harris and Pringle (1985) present the following unlevering beta equation

$$\beta_{i,t} = \frac{\beta_{i,t}^E}{1 + \frac{D_{i,t}}{E_{i,t}}}, \quad (10)$$

where $\beta_{i,t}^E$ is the equity beta for firm *i* at time *t*, and $\frac{D_{i,t}}{E_{i,t}}$ is the ratio of long-term debt to market value of equity. We use equation (10) to compute unlevered betas for our global sample as it addresses both of our concerns.

3.2.1 Relation of Growth Opportunities and a Firm's Unlevered Beta

Before establishing a distinction between the beta of growth opportunities β_t^G and the beta of assets-in-place β_t^A across industries, the magnitude affecting the firm's growth opportunities, their systematic risk, and thus their

[2] See Jacquier et al. (2010).

unlevered beta have to be empirically determined, which will in turn serve as a basis for the estimation of growth and asset betas.

Also, to examine the hypothesis that high growth opportunities indicate high unlevered betas, we compute unlevered firm betas for each industry to differentiate between betas of projects with below-average and above-average growth opportunities. Since the proportion of growth opportunities is proxied by book-to-market weights, firms are sorted based on their market-to-book ratio for each industry. Unlevered betas for firms within the market-to-book 25th and 75th percentile are separated. We then calculate the averages of these groups and the average of all betas for every industry during each time period.

3.2.2 Estimating the Beta of Assets-in-Place and the Beta of Growth Opportunities

The estimated mean beta of assets-in-place β_t^A and growth opportunities β_t^G is based on annual firm unlevered betas and the corresponding market-to-book ratios for each industry. At first, firms' unlevered betas are sorted according to their market-to-book values to determine whether high market-to-book ratios refer to higher firms' unlevered betas. We follow Bernardo et al. (2007), constructing two portfolios for sorted firms' unlevered betas and market-to-book ratios based on their yearly medians. In other words, we separate firms into two groups: firms with above-average and below-average growth opportunities based on the median of their market-to-book values. Next, we compute averages of the market-to-book ratios and firms' unlevered betas for each group so that finally, there are four values in each industry per year: a mean of the market-to-book ratios $MB_{H,t}$ (D+E) and unlevered betas $\beta_{H,t}$ for the firms with high H growth opportunities and $MB_{L,t}$ (D+E) as $\beta_{L,t}$ for those with low L growth opportunities.

We rewrite equation (8) for the empirical analysis as $\beta_{i,t} = \beta_t^G - \left(\beta_t^G - \beta_t^A\right)\frac{B_{i,t}}{M_{i,t}}$ and modify it in such a way that a unlevered beta is a direct function of the market-to-book ratio $MB_{i,t}$ (D+E) to streamline the interpretation:

$$\beta_{i,t} = \frac{\beta_t^A - \beta_t^G\left(1 - MB_{i,t}\right)}{MB_{i,t}} \quad . \tag{11}$$

Bernardo et al. (2007) determine β_t^A and β_t^G with a regression model based on the H and L portfolios' averages. This paper presents an alternative with the following analytical equations (12) and (13) entirely consistent with their regression approach.[3]

$$\beta_t^G = \frac{MB_{L,t}\beta_{L,t} - MB_{H,t}\beta_{H,t}}{MB_{L,t} - MB_{H,t}} \tag{12}$$

$$\beta_t^A = \frac{\dfrac{MB_{L,t}\beta_{L,t}}{1 - MB_{L,t}} - \dfrac{MB_{H,t}\beta_{H,t}}{1 - MB_{H,t}}}{\dfrac{1}{1 - MB_{L,t}} - \dfrac{1}{1 - MB_{H,t}}} \tag{13}$$

4. Results

[3]As a robustness check, we perform cross-sectional regressions in section 4.2., to test whether using all individual stocks (equal-weighted) leads to similar inferences as the reduction to two dimensions H and L (equal-weighted portfolios).

We report the results for the worldwide sample across 32 industries selected from the ICB classification over the period 1980-2008. Gauging the time-period stability of our results, we further split the sample into subperiods from 1980-1989, 1990-1999, and 2000-2008.

4.1. Global Sample

Table 2 shows the relationship between growth opportunities and firms' unlevered betas within a given industry. We hypothesize that a relatively huge amount of growth opportunities (high market-to-book ratio) is accompanied by higher firm betas. We remarkably confirm the Bernardo et al. (2007) results with our powerful out-of-sample study across all industries and over all periods. Firms with above-average growth opportunities have higher unlevered betas (represented in column Q3, the upper MB quartile, “growth”) than firms with below-average growth opportunities (betas in column Q1, the lower MB quartile, “value”). The difference is positive and significant at the 1%-level (unreported) for all periods and all industries.

Table 2: Averages of Industrial Unlevered Betas at the Global Level

This table documents averages of firm unlevered betas across industries. Firm betas are computed by estimating levered equity betas using the market model on a 60-month rolling window and unlevering them with the Harris and Pringle (1985) model. Averages of unlevered betas for all firms (column Mean), unlevered betas for firms with below-average growth opportunities (column Q1, the lower quartile according to the market-to-book ratio based on debt and equity, “value” firms), and above-average growth opportunities (column Q3, the upper quartile according to the market-to-book ratio based on debt and equity, “growth” firms) are calculated by sorting the firms in each industry respective to their market-to-book ratios across all years in each period. Averages are reported for the entire sample 1980-2008 period consisting of 29 years, and the subperiods 1980-1989, 1990-1999, and 2000-2008.

	1980 - 2008			1980 - 1989			1990 - 1999			2000 - 2008		
Industry	Q1	Mean	Q3	Q1	Mean	Q3	Q1	Mean	Q3	Q1	Mean	Q3
Aerospace and Defense	0.690	0.859	1.032	0.702	0.910	1.055	0.589	0.761	0.864	0.783	0.904	1.104
Alternative Energy	0.981	1.234	1.444	1.230	1.358	1.505	0.396	0.709	1.196	1.110	1.291	1.521
Automobiles and Parts	0.659	0.718	0.833	0.626	0.721	0.735	0.659	0.744	0.880	0.661	0.699	0.821
Beverages	0.581	0.658	0.732	0.578	0.713	0.787	0.568	0.691	0.774	0.587	0.620	0.647
Chemicals	0.672	0.762	0.868	0.678	0.750	0.774	0.678	0.793	0.903	0.673	0.741	0.857
Construction and Materials	0.684	0.752	0.898	0.573	0.751	0.835	0.650	0.768	0.930	0.714	0.741	0.878
Electronic and Electrical Equipment	0.848	0.967	1.101	0.810	0.930	0.995	0.785	0.900	1.013	0.872	1.012	1.202
Electricity	0.449	0.470	0.677	0.224	0.339	0.562	0.417	0.448	0.686	0.549	0.541	0.693
Fixed Line Telecommunications	0.666	0.767	0.924	0.278	0.482	0.796	0.460	0.732	0.900	0.821	0.826	0.930
Food and Drug Retailers	0.504	0.643	0.804	0.559	0.718	0.900	0.530	0.653	0.785	0.506	0.613	0.797
Food Producers	0.627	0.687	0.807	0.618	0.721	0.791	0.644	0.734	0.861	0.622	0.650	0.744
Forestry and Paper	0.617	0.647	0.798	0.756	0.758	0.837	0.575	0.674	0.873	0.640	0.606	0.707
Gas, Water and Multi-Utilities	0.435	0.488	0.686	0.330	0.439	0.721	0.476	0.516	0.736	0.470	0.491	0.632
General Industrials	0.652	0.747	0.900	0.605	0.762	0.933	0.616	0.766	0.936	0.700	0.728	0.837
General Retailers	0.641	0.828	1.068	0.584	0.879	1.135	0.633	0.812	1.040	0.662	0.828	1.063
Healthcare Equipment and Services	0.765	0.945	1.171	0.766	0.945	1.042	0.717	0.935	1.163	0.787	0.951	1.174
Household Goods and Home Construction	0.663	0.768	0.902	0.744	0.859	0.933	0.641	0.785	0.936	0.675	0.730	0.854
Industrial Engineering	0.731	0.820	0.953	0.615	0.764	0.827	0.735	0.822	0.928	0.754	0.832	1.000

Table 2: Averages of Industrial Unlevered Betas at the Global Level (continued)

	1980 - 2008			1980 - 1989			1990 - 1999			2000 - 2008		
Industry	Q1	Mean	Q3	Q1	Mean	Q3	Q1	Mean	Q3	Q1	Mean	Q3
Industrial Metals and Mining	0.715	0.813	1.025	0.653	0.718	0.801	0.685	0.781	0.936	0.719	0.851	1.143
Industrial Transportation	0.538	0.662	0.870	0.548	0.718	0.982	0.505	0.665	0.874	0.558	0.651	0.850
Leisure Goods	0.753	0.897	1.069	0.805	0.899	0.994	0.701	0.843	1.007	0.774	0.929	1.119
Media	0.736	0.873	1.056	0.696	0.855	0.944	0.593	0.733	0.880	0.789	0.936	1.158
Mining	0.828	1.025	1.230	0.557	0.806	1.131	0.644	0.852	1.112	0.982	1.109	1.267
Mobile Telecommunications	0.758	0.904	1.119	0.198	0.483	0.881	0.886	0.958	1.260	0.810	0.920	1.092
Oil and Gas Producers	0.699	0.791	0.961	0.673	0.762	0.875	0.674	0.729	0.824	0.706	0.828	1.033
Oil Equipment and Services	0.732	0.882	1.155	0.716	0.835	1.094	0.736	0.830	1.056	0.734	0.913	1.185
Personal Goods	0.653	0.736	0.871	0.646	0.757	0.805	0.611	0.753	0.918	0.682	0.720	0.846
Pharmaceuticals and Biotechnology	0.847	1.046	1.271	0.714	0.872	0.914	0.801	1.025	1.271	0.886	1.080	1.314
Software and Computer Services	1.101	1.258	1.400	0.802	1.013	1.213	0.918	1.122	1.307	1.138	1.300	1.461
Support Services	0.680	0.847	1.049	0.618	0.816	1.022	0.630	0.795	0.978	0.709	0.880	1.110
Technology Hardware and Equipment	1.042	1.274	1.541	0.867	1.114	1.265	0.903	1.126	1.418	1.073	1.362	1.693
Travel and Leisure	0.567	0.682	0.902	0.601	0.730	0.885	0.602	0.721	0.960	0.550	0.652	0.863

Table 2 highlights that distinguishing between industries when estimating the cost of capital is critical. Moreover, assessing the magnitude of growth opportunities for a specific investment project within an industry is crucial. The difference in firm betas with high and low growth opportunities lies between 0.15 and 0.50 for the global 1980-2008 sample period. Our results correspond nicely to the Bernardo et al. (2007) results ranging from .00 to .45 for the U.S. 1977-2004 sample period.

Sorting by growth opportunities can alter the unlevered cost of capital by up to 3 percentage points using an overall 6% market equity risk premium in an international context. Note that this premium is a conservative estimate considering over 100 years of international market data as documented by Brealey et al. (2023) with their figure 7.3. For example, we calculate this variation in the cost of capital for Food and Drug Retailers. Over the total time period, the average unlevered firm beta in this sector is 0.643. However, a value firm (Q1) has a unlevered beta of 0.504, while a growth firm (Q3) has a unlevered beta of 0.804. The difference in this sector means a 1.8 percentage points higher cost of capital for a growth firm relative to a value firm.

Table 3: Averages of Asset and Growth Betas across Industries at the Global Level

This table reports the beta of growth opportunities and assets-in-place, as well as the difference between them across all industries, averaged over the same periods. Annual asset and growth betas are determined by equations (12) and (13) from unlevered betas (reported in Table 2) and firms' market-to-book ratios, both sorted by high and low growth opportunities. Statistical significance of the difference between the growth and asset beta is measured by a t-test (column t-test) and a nonparametric Wilcoxon rank-sum test (column w-test), where *, **, and *** indicate significance at the 10%-, 5%-, 1%-levels, respectively.

Industry	1980 - 2008					1980 - 1989					1990 - 1999					2000 - 2008				
	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test
Aerospace and Defense	0.760	1.125	0.365	***	***	0.799	1.332	0.533	***	***	0.702	1.009	0.307	***	***	0.781	1.023	0.242	***	**
Alternative Energy	0.237	1.380	1.143		*	-	-	-			-0.630	1.223	1.852		**	1.199	1.554	0.355		**
Automobiles and Parts	0.685	0.871	0.186	***	***	0.704	0.890	0.186	*		0.670	0.950	0.281	***	***	0.681	0.763	0.081		*
Beverages	0.618	0.786	0.168	***	***	0.660	0.839	0.179	***	***	0.583	0.852	0.269	***	***	0.610	0.653	0.043	*	
Chemicals	0.724	0.879	0.154	***	***	0.697	0.885	0.187	***	***	0.745	0.926	0.181	***	***	0.731	0.820	0.088	*	
Construction, Materials	0.709	0.929	0.220	***	***	0.673	1.012	0.339	***	***	0.713	0.966	0.253	***	***	0.743	0.795	0.052		
Electronic, Electrical Eq.	0.881	1.120	0.239	***	***	0.789	1.156	0.367	***	***	0.855	1.035	0.180	***	***	1.011	1.174	0.163	***	**
Electricity	0.359	0.713	0.354	***	***	0.264	0.792	0.529	***	***	0.322	0.723	0.401	***	***	0.504	0.612	0.107	*	*
Fixed Line Telecomm.	0.545	0.954	0.409	***	***	0.352	0.972	0.620	***	***	0.500	1.015	0.516	***	***	0.810	0.866	0.057		
Food and Drug Retailers	0.516	0.924	0.408	***	***	0.508	1.063	0.555	***	***	0.519	0.890	0.371	***	***	0.523	0.809	0.286	***	***
Food Producers	0.649	0.820	0.171	***	***	0.665	0.844	0.179	**	**	0.645	0.901	0.256	***	***	0.637	0.704	0.067	*	
Forestry and Paper	0.655	0.706	0.051		*	0.725	0.569	-0.157			0.638	0.924	0.286	***	***	0.594	0.616	0.021		
Gas, Water, Multi-Util.	0.387	0.802	0.415	***	***	0.323	0.967	0.644	***	***	0.390	0.806	0.415	***	***	0.454	0.614	0.161	***	***
General Industrials	0.684	0.968	0.284	***	***	0.642	1.097	0.455	***	***	0.698	0.989	0.291	***	***	0.715	0.801	0.087	**	*
General Retailers	0.705	1.149	0.445	***	***	0.646	1.301	0.655	***	***	0.705	1.087	0.381	***	***	0.770	1.051	0.281	***	***
Healthcare Eq., Services	0.828	1.167	0.339	***	***	0.810	1.217	0.407	***	***	0.782	1.180	0.398	***	***	0.899	1.099	0.199	**	**
Household Goods	0.748	0.924	0.176	***	***	0.790	1.019	0.229	***	***	0.728	0.925	0.197	***	***	0.724	0.818	0.094	*	
Industrial Engineering	0.752	0.954	0.202	***	***	0.695	1.008	0.313	***	***	0.749	0.935	0.187	***	***	0.819	0.915	0.095		
Industrial Metals, Min.	0.720	0.930	0.210	***	***	0.669	0.856	0.187	***	***	0.720	0.966	0.246	***	***	0.777	0.973	0.196		
Industrial Transportation	0.582	0.966	0.384	***	***	0.605	1.030	0.424	***	***	0.533	1.013	0.480	***	***	0.610	0.843	0.233	***	***
Leisure Goods	0.814	1.044	0.230	***	***	0.831	1.017	0.186			0.748	1.026	0.278	***	***	0.869	1.096	0.227	***	***

Table 3: Averages of Asset and Growth Betas across Industries at the Global Level (continued)

	1980 - 2008					1980 - 1989					1990 - 1999					2000 - 2008				
Industry	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test
Media	0.739	1.036	0.296	***	***	0.675	1.150	0.474	***	***	0.703	0.844	0.141	***	**	0.850	1.121	0.271	***	***
Mining	0.871	1.190	0.318	***	***	0.763	1.333	0.571	***	***	0.779	1.110	0.332	***	***	1.094	1.118	0.024		
Mobile Telecom.	0.527	1.189	0.662	***	***	0.113	1.254	1.142	***	***	0.778	1.145	0.367	**	**	0.708	1.166	0.458	***	***
Oil and Gas Producers	0.677	0.941	0.264	***	***	0.730	0.964	0.234	***	**	0.617	0.911	0.294	***	***	0.686	0.949	0.263	***	***
Oil Equipment, Services	0.658	1.196	0.537	***	***	0.676	1.156	0.480	**	**	0.626	1.133	0.507	***	***	0.674	1.309	0.635	***	***
Personal Goods	0.714	0.872	0.159	***	***	0.718	0.899	0.181	**	*	0.703	0.930	0.227	***	***	0.720	0.777	0.058		
Pharmaceuticals, Biotech.	0.958	1.160	0.202	*	***	0.745	1.019	0.274	***	***	1.106	1.226	0.120		**	1.031	1.244	0.212		**
Software, Computer Ser.	1.040	1.331	0.292	***	***	0.769	1.364	0.595	***	***	1.006	1.247	0.241	**	*	1.377	1.389	0.011		
Support Services	0.764	1.070	0.306	***	***	0.642	1.189	0.548	***	***	0.694	0.989	0.296	***	***	0.979	1.029	0.050		
Tech. Hardware and Eq.	0.988	1.488	0.500	***	***	0.828	1.452	0.624	***	***	0.891	1.378	0.487	***	***	1.273	1.651	0.377	**	**
Travel and Leisure	0.616	0.920	0.303	***	***	0.636	0.936	0.300	***	***	0.633	0.971	0.339	***	***	0.576	0.845	0.269	***	***

Table 3 reports betas of assets-in-place and growth opportunities determined by equations (12) and (13). It is evident that growth betas are larger than asset betas $\left(\beta_t^G > \beta_t^A\right)$ over the entire period across all industries, statistically significant for 29 of the 32 industries at the 1%-level when using the t-test. The Wilcoxon rank-sum test reports even 30 industries at this significance level. The highest positive and statistically significant difference between these betas amounts to 0.662 for the Mobile Telecommunications industry. This result implies that the difference in the cost of capital between a growth company or startup venture in that industry and a well-established firm with only a few growth options could be up to 4 percentage points, assuming a 6% market risk premium. Our mostly out-of-sample analysis corroborates the results of Bernardo et al. (2007) remarkably. Although the papers use alternative sector classifications, it is comforting that the highest statistically significant difference of Mobile Telecommunications corresponds to theirs, which is in Communication with 1.047. Looking at subperiods, we observe a relatively consistent behavior over time. Again, all statistically significant differences are positive. At the same time, statistical significance levels fluctuate more over these short subperiods, which we would expect. To sum up, the theoretical evidence provided in section 2 finds empirical support.

4.2 Robustness Check

Additionally, we perform a robustness check to examine whether our initial methodology holds up a more refined specification. For this purpose, we bring equation (8) directly to the data using the following cross-sectional regression in equation (14).

$$\widehat{\beta}_{i,t} = \beta_t^G - \left(\beta_t^G - \beta_t^A\right)\frac{B_{i,t}}{M_{i,t}} + \varepsilon_{i,t}, \qquad (14)$$

where $\varepsilon_{i,t}$ indicates the measurement error in the estimate of the firm's unlevered beta $\widehat{\beta}_{i,t}$ and $\frac{B_{i,t}}{M_{i,t}}$ is the book-to-market weight measured for debt and equity.

We estimate the annual asset and growth beta for the unlevered beta based on equations (10) and (14). The intercept represents the growth beta β_t^G and the slope coefficient $\beta_t^A - \beta_t^G \left(= -\left(\beta_t^G - \beta_t^A\right)\right)$ is the difference between the asset and growth beta. Table 4 summarizes the resulting growth and asset beta estimates, documenting that the empirical results bear exceptionally well across industries in this robustness check at the individual stock level.

Table 4: Robustness Check of Averages of Asset and Growth Betas across Industries at the Global Level

This table exhibits the beta of growth opportunities and assets-in-place, as well as the difference between them across all industries, averaged over the same periods. Annual asset and growth betas are estimated from a firm's unlevered beta based on equation (10) using the cross-sectional regression in equation (14) to estimate the intercept (growth beta) and slope coefficient (difference between the asset and growth beta). Statistical significance of the difference between the growth and asset beta is measured by a t-test (column t-test) and a nonparametric Wilcoxon rank-sum test (column w-test), where *, **, and *** indicate significance at the 10%, 5%, 1% levels, respectively.

	1980 - 2008					1980 - 1989					1990 - 1999					2000 - 2008				
Industry	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test
Aerospace and Defense	0.790	1.108	0.318	***	***	0.835	1.310	0.476	***	***	0.724	0.989	0.265	***	***	0.815	1.017	0.202	**	**
Alternative Energy	0.200	1.369	1.168		*	-	-	-			-0.629	1.224	1.853		**	1.121	1.529	0.408	***	***
Automobiles and Parts	0.700	0.850	0.150	***	***	0.704	0.898	0.194	**		0.704	0.895	0.191	***	***	0.693	0.748	0.055		*
Beverages	0.638	0.765	0.128	***	***	0.660	0.844	0.184	***	***	0.631	0.815	0.183	***	***	0.619	0.623	0.004		
Chemicals	0.743	0.841	0.098	***	***	0.718	0.827	0.109	***	***	0.783	0.880	0.097	***	**	0.728	0.814	0.087		
Construction and Mat.	0.717	0.883	0.166	***	***	0.692	0.939	0.247	***	***	0.727	0.932	0.206	***	**	0.734	0.765	0.031		
Electronic and Elec. Eq.	0.880	1.099	0.218	***	***	0.809	1.165	0.356	***	***	0.848	1.008	0.159	***	***	0.995	1.126	0.131	**	*
Electricity	0.390	0.716	0.326	***	***	0.272	0.970	0.698	***	***	0.392	0.597	0.205	***	***	0.518	0.566	0.048		
Fixed Line Telecomm.	0.573	1.017	0.444	***	***	0.365	1.188	0.823	***	***	0.570	0.973	0.402	***	***	0.806	0.875	0.069		

Food, Drug Retailers	0.583	0.849	0.266	***	***	0.595	0.982	0.387	***	***	0.593	0.803	0.210	***	***	0.560	0.753	0.193	***	***
Food Producers	0.673	0.789	0.117	***	***	0.682	0.817	0.135	**	**	0.692	0.858	0.166	***	***	0.641	0.683	0.042		
Forestry and Paper	0.660	0.698	0.037			0.718	0.604	-0.114			0.654	0.862	0.207	**		0.603	0.620	0.017		
Gas, Water, Multi-Util.	0.405	0.828	0.423	***	***	0.331	1.092	0.761	***	***	0.422	0.788	0.367	***	***	0.470	0.580	0.110	**	**
General Industrials	0.706	0.933	0.228	***	***	0.681	1.059	0.378	***	***	0.716	0.981	0.264	***	***	0.722	0.742	0.020		
General Retailers	0.783	1.001	0.218	***	***	0.787	1.047	0.260	***	***	0.774	1.008	0.234	***	***	0.788	0.943	0.155	**	**
Healthcare Eq. and Ser.	0.840	1.160	0.320	***	***	0.828	1.237	0.409	***	***	0.834	1.133	0.299	***	***	0.858	1.103	0.245	***	***
Househ. Goods	0.764	0.915	0.151	***	***	0.812	1.022	0.210	***	***	0.754	0.920	0.167	***	***	0.722	0.790	0.068		
Industrial Engineering	0.772	0.933	0.161	***	***	0.735	0.982	0.246	***	***	0.771	0.937	0.166	***	***	0.813	0.875	0.062		
Industrial Met., Min.	0.750	0.892	0.142	***	***	0.682	0.833	0.150	***	***	0.764	0.903	0.139	***	**	0.811	0.946	0.135		
Industrial Transport.	0.611	0.932	0.321	***	***	0.604	1.144	0.539	***	***	0.602	0.884	0.282	***	***	0.629	0.752	0.122	*	
Leisure Goods	0.821	1.041	0.220	***	***	0.803	1.091	0.288	***	***	0.775	1.010	0.235	***	***	0.892	1.020	0.127	**	*

Table 4: Robustness Check of Averages of Asset and Growth Betas across Industries at the Global Level (continued)

	1980 - 2008					1980 - 1989					1990 - 1999					2000 - 2008				
Industry	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test	Asset	Growth	Diff	t-test	w-test
Media	0.780	0.962	0.182	***	***	0.789	1.056	0.267	***	***	0.664	0.832	0.168	***	***	0.897	1.002	0.105		
Mining	0.883	1.167	0.284	***	***	0.843	1.331	0.488	***	***	0.818	1.061	0.242	***	***	1.000	1.103	0.103		
Mobile Telecomm.	0.565	1.175	0.611	***	***	0.164	1.235	1.071	***	***	0.787	1.150	0.363	**	**	0.763	1.136	0.374	***	***
Oil and Gas Producers	0.698	0.929	0.231	***	***	0.721	0.985	0.264	***	***	0.659	0.870	0.212	***	***	0.718	0.931	0.214	**	**
Oil Equipment and Ser.	0.729	1.127	0.398	***	***	0.720	1.163	0.443	**	***	0.702	1.063	0.362	***	***	0.768	1.157	0.389	***	***
Personal Goods	0.729	0.843	0.114	***	***	0.736	0.869	0.133	***	***	0.734	0.898	0.165	***	***	0.717	0.753	0.036		
Pharma. and Biotech	0.832	1.161	0.328	***	***	0.743	1.039	0.297	***	***	0.835	1.217	0.383	***	***	0.929	1.233	0.303	***	***
Software and Com. Ser.	1.019	1.273	0.254	***	***	0.847	1.259	0.412	***	***	0.969	1.211	0.242	***	***	1.265	1.356	0.091		
Support Services	0.744	1.049	0.305	***	***	0.708	1.164	0.456	***	***	0.714	0.951	0.237	***	***	0.817	1.031	0.214	***	**
Tech. Hardware and Eq.	1.049	1.432	0.383	***	***	0.904	1.440	0.536	***	***	0.978	1.318	0.340	***	***	1.288	1.548	0.260	**	***
Travel and Leisure	0.654	0.848	0.194	***	***	0.651	0.897	0.246	***	***	0.696	0.872	0.176	***	***	0.610	0.767	0.156	***	**

5. Conclusions

This paper explores the impact of growth opportunities on the cost of equity around the world by virtue of an international sample of 28 developed and 22 emerging markets.

First, our results corroborate that a high magnitude of a firm's growth opportunities leads to a high firm's unlevered beta. Failure to account for this can underestimate the industry cost of equity by up to 3 percentage points, depending on the industry. Second, we establish that the beta of growth opportunities exceeds the beta of assets-in-place for the majority of industries. Hence, the beta of growth opportunities seems to be a suitable measure of risk for nascent startup ventures. In contrast, the beta of assets-in-place is more reasonable for well-established mature firms. Consequently, these betas can be used to discount projected cash flows of a specific industry taking into account the phase of the company life cycle.

We provide ample evidence that several factors determine empirically the cost of capital estimation. These are the magnitude of growth opportunities (especially the distinction between mature and startup firms) and the industry.

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Appendix A: **Relationship between Growth Option and Beta**

It is helpful to begin with the stochastic differential equation by Black and Scholes (1973) to link the option pricing model with the CAPM. The following explanations are based on Copeland and Weston (1988), and Copeland et al. (2005). First of all, Ito's lemma is applied to express the change in the call option price depending on the underlying stock price and time $C(S,t)$:

$$dC = \frac{\partial C}{\partial S} dS + \frac{\partial C}{\partial t} dt + \frac{1}{2}\frac{\partial^2 C}{\partial S^2}\sigma^2 S^2 dt \quad \text{(A.1)}$$

Based on this, the call option is the value of a firm's growth opportunity G, with the value of its assets-in-place A as the underlying. Therefore, equation (A.1) may be rewritten as

$$dG = \frac{\partial G}{\partial A} dA + \frac{\partial G}{\partial t} dt + \frac{1}{2}\frac{\partial^2 G}{\partial A^2}\sigma^2 A^2 dt \quad \text{(A.2)}$$

This means that the change in the value of a firm's growth opportunity dG is related to the change in the value of a firm's assets-in-place dA, movement of the growth opportunity across time, dt, and the instantaneous variance of the firm's value, σ^2. Dividing by G, we obtain the limit as dt approaches zero,

$$\lim_{dt\to 0} \frac{\partial G}{G} = \frac{\partial G}{\partial A}\frac{dA}{G} = \frac{\partial G}{\partial A}\frac{dA}{A}\frac{A}{G} \quad \text{(A.3)}$$

$\frac{\partial G}{G}$ is the rate of return of growth opportunities, r^G, and $\frac{dA}{A}$ is the rate of return on the firm's assets-in-place, r^A; therefore

$$r^G = \frac{\partial G}{\partial A}\frac{A}{G} r^A \quad \text{(A.4)}$$

The instantaneous systematic risk of growth opportunity, β^G and that of the firm's assets, β^A, are defined as

$$\beta^G \equiv \frac{\operatorname{cov}(r^G, r_M)}{\operatorname{var}(r_M)}, \text{ and } \beta^A \equiv \frac{\operatorname{cov}(r^A, r_M)}{\operatorname{var}(r_M)} \quad \text{(A.5)}$$

$\operatorname{cov}(.,.)$ is the covariance between two random variables, $\operatorname{var}(.,.)$ is the variance of a random variable, and r_M is the market return. We use (A.4) and (A.5) to rewrite the instantaneous β^G as[4]

$$\beta^G \equiv \frac{\partial G}{\partial A}\frac{A}{G}\frac{\operatorname{cov}(r^A, r_M)}{\operatorname{var}(r_M)} = \frac{\partial G}{\partial A}\frac{A}{G}\beta^A \quad \text{(4)}$$

For a more convenient exposition, we assume $\beta^G \equiv \beta_t^G$, $\beta^A \equiv \beta_t^A$, $G \equiv G_t$, and $A \equiv A_t$.

[4] See Copeland and Weston (1988), p. 466.

Appendix B: $\beta_t^G > A_t^A$

Inserting equation (3) into (5), we receive

$$\beta_t^G = \frac{N(d_1)A_t}{A_t N(d_1) - I_t e^{-rT} N(d_2)} \beta_t^A$$

$$= \frac{1}{1 - \frac{N(d_2)I_t}{N(d_1)A_t} e^{-rT}} \beta_t^A \qquad \text{(A.6)}$$

If $\frac{I_t}{A_t} \leq 1$, $e^{-rT} < 1$, $N(d_2) < N(d_1)$, and - for logical reasons- that A_t and G_t have to be larger than zero, it is true that $\frac{N(d_1)A_t}{G_t} > 1$.[5]

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[5] See Copeland et al. (2005), p. 583-584.