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Growth Options and Risk

An Empirical Analysis of the Relation between Growth Options and Unlevered Beta

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Abstract

Estimating risk is an important part of capital budgeting and valuation because risk affects the cost of capital. Firms and projects consist of both assets-in-place and growth options and it is typically assumed that growth options are riskier. This thesis examines the relation between growth options and risk. We base our research on the framework proposed by Bernardo, Chowdhry and Goyal (2007), who show that firms with high proportions of growth options relative to assets-in-place have higher unlevered betas. We apply a cross-sectional regression model for examining the effect growth options have on the unlevered beta in the time period 1990-2013 and the subsamples, 1995-2004 and 2005-2013. Our results show that accounting for growth options in determining the unlevered beta is not necessarily important for all industries and all time periods. Such findings have important practical implications for firms that base their investment decisions and valuation on the method of comparables. Our contradicting results shed new light on previous research, indicating an inconsistent relation between growth options and the unlevered beta across industries and time periods.

Preface

The inspiration for this study was formed during courses at the master level of the Norwegian School of Economics (NHH). As students from different master programmes, it was important for us to find a subject that was interesting and relevant to us both. Before deciding upon a research area, we discussed potential subjects thoroughly with several professors at the school. Eventually, we discovered that growth options in combination with investment decisions, valuation and risk was interesting, challenging, and important for practical reasons.

Throughout the process of this master thesis, we have been able to apply the knowledge we have gained over the last four years at this school. We have also gained some profound new insight within a specific field. For this, we are grateful. Prior to writing this master thesis, we had taken econometric courses, introductory corporate finance courses and courses within investment analysis. We have therefore developed skills within empirical testing and an understanding of capital budgeting, valuation and option theory, but we did not possess advanced knowledge about how growth options affect the risk of firms and projects.

We would like to sincerely thank our supervisor, Associate Professor Michael Kisser, for introducing us to the topic and for his help during the process of writing this thesis. He has been engaged in our work and given us constructive feedback. At the same time, he has challenged us to work independently. We will also like to thank Nikhil Atreya, Ph.D. student at NHH, for constructive suggestions and Melissa Graebner, Associate Professor at McCombs School of Business, for establishing contact with a graduate student for linguistic feedback.

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1. Introduction

1.1 Background

A basic intuition is that firms operate to create value for its shareholders. Such value creating activities may include engaging in projects or even other firms. All firms have limited resources, and can therefore not invest in all profitable investment opportunities they might face. The process of choosing among potential investment opportunities is often referred to as capital budgeting. The process involves estimating what future cash flows the firm or project may yield. Due to the time value of money, such future cash flows should be discounted by an appropriate discount factor denoted the cost of capital, in order to make them comparable. It is well known that the cost of capital represents the rate of return on the best alternative investment with similar maturity and risk. Thus, an important determinant of the cost of capital is the risk of the investment opportunity, which is typically measured by the so-called beta component. For public firms, this beta can be calculated based on transparent and publicly listed information. For private firms and investment projects, however, the beta is not observable in a market and needs to be determined using other methods, typically by applying comparable firms. Since the value of a firm and project consists of the value of existing assets-in-place and the present value of its opportunities to grow, the overall risk will be affected by both. Considering the risk of assets-in-place and growth opportunities is therefore important in order to determine the appropriate overall beta.

This study will analyse the relation between growth opportunities and beta. We base our analysis on a framework suggested by Bernardo, Chowdhry and Goyal (2007). By decomposing the firm's unlevered beta into the beta of assets-in-place and beta of growth opportunities, they show that the beta of growth opportunities is greater than the beta of assets-in-place for virtually all industries over all periods of time dating back to 1977. If growth opportunities generally increase the unlevered beta, this has important practical implications for private firms and projects, which depend on using the method of comparables for estimating the unlevered beta. The findings of Bernardo et al. (2007) would imply that it is crucial for private firms and project managers to match their growth opportunities to the ones of peer public firms in order to determine an appropriate unlevered beta.

1.2 Research Question

The purpose of this study is to empirically test whether growth opportunities increase the unlevered beta. Based on previous research, we propose the following hypothesis:

The beta of growth opportunities exceeds the beta of assets-in-place, implying that the unlevered beta increases with growth opportunities.

1.3 Further Structure

The remaining parts of this thesis are structured as follows. Section 2 presents literature related to capital budgeting, valuation and option theory. Section 3 describes the framework and results of Bernardo et al. (2007). Section 4 discusses the preparation of our data. Section 5 provides our empirical results and analysis, together with some practical implications. Finally, we conclude in Section 6.

2. Literature Review

In this section, we present literature related to our research area. In Section 2.1, we first discuss the importance of capital budgeting and valuation. Further, we present literature related to the development of the Capital Asset Pricing Model (CAPM) and alternative asset-pricing models. In addition, we provide literature concerning risk and its relation to growth opportunities. In Section 2.2, we present literature related to option valuation through the Black-Scholes model and the replicating portfolio.

2.1 Capital Budgeting and Valuation

2.1.1 The Importance of Capital Budgeting and Valuation

One of the main reasons why firms exist is to create value for their shareholders. Value creation can be achieved by investing in profitable projects. Engaging in projects will result in future cash flows, which entails that firms have to estimate whether the project is worth investing in. Even though an investment opportunity contributes with a positive net present value, it is not necessarily optimal for firms to invest. The reason is that firms have scarce resources that constrain them from investing in all profitable investment opportunities. Jagannathan and Meier (2002) argue that by choosing one investment project firms give up the opportunity to undertake an even more attractive investment project later on. For this reason, choosing the optimal investment project is crucial and should be based on a valuation in present time. Jagannathan and Meier (2002) emphasize that this has become a common practice, as they report that by the late 1970s most financial executives were using methods like the discounted cash flow analysis to value investment projects. The discounted cash flow analysis gives guidelines on which investment projects a firm should undertake by dividing a project's future cash flows less the initial investment by an appropriate cost of capital. Estimating future cash flows and the appropriate cost of capital is also important in valuation of assets and firms in order to predict what the they are worth in present time. In order to make the right investment decisions and accurate valuations, it is therefore crucial for firms to estimate the inputs of the discounted cash flow analysis correctly.

2.1.2 The Capital Asset Pricing Model

According to Graham and Harvey (2001), the CAPM is by far the most popular method for estimating the cost of capital in practice. They find that 73.5 % of the 392 CEO respondents always or almost always use the CAPM when estimating the cost of capital. Since the CAPM is obviously important in practice, it is essential that the method is implemented correctly.

The CAPM, which was first developed by Sharpe and Lintner, states that the cost of capital is a function of the risk-free rate, the overall beta and the market risk premium (Sharpe, 1964 & Lintner, 1965):

$$E(r) = r_f + \beta(r_m - r_f)$$

where r_f is the risk-free rate, β denotes the overall beta and $r_m - r_f$ represents the market risk premium.

The CAPM is based on, among others, the assumption that investors can take short or long positions of unlimited size, in both risky and riskless assets, and lend and borrow unlimited amounts at the riskless interest rate (Black, 1972). Black (1972) suggests that this assumption might be an incorrect approximation of the real world. He argues that it is not realistic for investors to face unlimited access to riskless assets and riskless borrowing. Black (1972) continues to assume that riskless assets exist, but does only allow for unlimited long and short positions in risky assets. He further assumes that only long positions are allowed in riskless assets. This modified version is called the Sharpe-Lintner-Black CAPM (SLB-CAPM). However, Black (1972) finds that the expected return on all assets is a linear function of its beta, which is consistent with the initial CAPM.

2.1.3 Criticism of the CAPM

The CAPM framework has been subject to criticism by, among others, Fama and French (1992, 1993). Fama and French (1992, p. 428) study "the joint roles of market beta, size, E/P, leverage and book-to-market equity in a cross-section of average stock returns on NYSE, AMEX and NASDAQ stocks". They show that there is a strong relation between average return and size, while they do not find a relation between average return and beta. The beta has no explanatory power even when it is the only independent variable included. Fama and French (1992) also find that there is a strong relation between cross-sectional average returns and book-to-market equity. In fact, they find that "the combination of size and book-to-market equity seems to absorb the roles of leverage and E/P in average stock returns, at least during our 1963-1990 sample period" (Fama & French, 1992, p. 428). The findings of Fama and French (1992) contradict the simple relation between average return and beta as predicted by the CAPM. These results are important, although project analysis in practice typically ignores it (Graham & Harvey, 2001).

2.1.4 The Fama French Three-Factor Model

Fama and French (1993) extend their asset-pricing tests in Fama and French (1992) and develop an alternative model, known as the Fama French Three-Factor Model, to explain the cross-section of average stock return. The model is empirically based and proposes that the cross-section of average stock return can be explained by three risk factors, namely the market risk factor, the firm size and book-to-market equity ratio. The size effect, also known as small-minus-big (SMB), is measured as the difference in average returns between stocks with a small and a high market capitalization. The effect of the book-to-market equity ratio, called high-minus-low (HML), is captured by the difference in average return between stocks with a high and a low book-to-market equity ratio. The market risk factor is analogous, but not equal, to the overall beta in the CAPM. Fama and French (1993) continue to include the market risk factor because there is a link between the stock market and the bond market, which size and book-to-market equity ratio alone does not fully capture. Fama and French (2004) point out that from a theoretical perspective, the main shortcoming of the Three-Factor Model is related to its empirical motivation. Fama and French (2004) recognize that the additional risk factors are constructed in order to capture how average stock returns vary with size and the book-to-market equity ratio. Thus, the additional risk factors are not motivated by predictions regarding the variables concerning investors.

2.1.5 Systematic and Unsystematic Risk

One key input of capital budgeting and valuation is risk caused by the uncertainty inherent in future cash flows. Sharpe (1964) divides the total risk of an asset into two components, the systematic and unsystematic risk. According to Sharpe (1964), the systematic risk denotes the risk that is correlated with the market portfolio, while the unsystematic risk represents the remaining part. Sharpe (1964) further argues that unsystematic risk can be diversified away, leaving investors with compensation for the systematic risk only. Sharpe (1964) and Lintner (1965) measure systematic risk of an asset by the beta component in the CAPM. The positive relation between beta and cost of capital entails that assets with high systematic risk will have higher cost of capital than assets with low systematic risk.

2.1.6 The Beta Component

The beta component is typically estimated using regression analysis (Fama & MacBeth, 1973). Such analysis requires that historical records of returns are available. Historical records are, however, only available for traded securities. For private firms and investment projects, which are not publicly traded, the beta must be estimated differently. Graham and Harvey (2001) show that for investment projects this issue is, in practice, often solved by using the firm's overall beta, and argue that this approach is likely to be inaccurate.

2.1.7 Comparables

Bowman and Bush (2006) suggest that private firms and divisions should estimate their beta by applying so-called comparable company analysis. This implies using average betas of comparable public firms as a proxy. Bowman and Bush (2006) investigate size, operating leverage, sales growth, dividend payout ratio, price-earnings ratio and book-to-market ratio in the estimation of beta for non-traded firms. The beta is also adjusted for financial leverage as it is usually done. Bowman and Bush (2006, p. 18) find that "variables that are generally significant in the regression models are size, operating leverage and dividend payout ratio", and argues that resemblance in these variables improve the beta estimates. They also find that the beta estimates are further improved by including several firms. Bernardo et al. (2007) demonstrate the empirical relation between growth opportunities and the unlevered beta. They recommend also accounting for growth opportunities when deciding on appropriate comparables.

2.1.8 Risk of Assets-in-Place and Growth Opportunities

It is well known in the financial literature that the value of a firm consists of the value of assets-in-place and the present value of its growth opportunities. This implies that the firm's overall risk is affected by both the risk of the assets-in-place and the risk of growth opportunities. Myers and Turnbull (1977) state that the systematic risk of growth opportunities differs from the risk of the opportunities' underlying asset; in fact, they argue that it is usually greater. Thus, the overall beta of the firm's stock will increase as the value of growth opportunities becomes larger relative to the value of assets-in-place. Chung and Charoenwong (1991) find empirical results that there exits a positive relation between the equity beta of a firm and different proxies for growth opportunities. They also claim that growth opportunities account for a considerable part of a firm's market value of equity, which emphasize the importance of considering growth opportunities when deciding upon comparables. Support for these findings are also given by Bernardo et al. (2007), who show that the beta of growth opportunities exceeds the beta of assets-in-place for virtually all industries dating back to 1977.

In the financial literature, there are different theories for why one could expect that the beta of growth opportunities is greater than the beta of assets-in-place. Berk, Green and Naik (1998) consider new venture projects. They argue that continuing with a new venture project depends on the outcome of systematic risk. New venture projects develop in stages and the firm continuously needs to decide whether to proceed to the next stage, suspend or abandon the project. This can be regarded as a compounded option, which has higher systematic risk than the underlying assets-in-place because options impart implicit leverage. Berk, Green and Naik (1999) point out that firms frequently face new investment decisions. They argue that, holding other variables constant, firms will tend to choose those investments with lower risk. This will decrease the risk of assets-in-place relative to the risk of growth opportunities.

Dechow, Sloan and Soliman (2004) discuss another theory for why it is plausible to expect that the beta of growth opportunities is higher than the beta for assets-in-place. They find an expression for implied equity duration based on the traditional formula for bond duration. Their results indicate that equity betas increase with equity duration. Intuitively, growth opportunities represent possible future cash flows. Thus, the results of Dechow et al. (2004) imply that the beta of growth opportunities is higher due to a longer duration of its corresponding cash flows. Carlson, Fisher and Giammarino (2004) consider the leverage effect of options, and conclude that the riskiness of growth opportunities is greater than the riskiness of unlevered assets-in-place because growth opportunities have a leverage effect.

As mentioned above, it is important to consider the impact of growth opportunities on the firm's unlevered beta. However, growth opportunities are not observable, and must therefore be proxied by private firms and project managers in order to determine appropriate comparables. Several empirical studies have tested different proxies, and the book-to-market (or market-to-book) ratio have received explicit attention. For instance, Adam and Goyal (2000) test the market-to-book asset ratio, the market-to-book ratio of equity and the earnings-price ratio as proxy variables. They find that the market-to-book asset ratio is the most informative. Da, Guo and Jagannathan (2011) also find that using the book-to-market ratio to proxy growth is the best approach.

2.2 Option Theory

2.2.1 Options

When considering growth opportunities, it is necessary to understand option theory. Black and Scholes (1973, p. 637) state that “an option is a security giving the right to buy or sell an asset, subject to certain conditions, within a specified period of time”. The right to buy the asset is called a call option, while the right to sell the relevant asset is a put option. The financial literature distinguishes between so-called American and European options. An American option is an option that can be exercised any time up until the expiry date, while a European option can only be exercised on the specified expiry date. Further, options are typically split into financial options and real options. A financial option is a right, but not an obligation to sell or buy a financial asset, such as a stock. A real option, on the other hand, is the right, but not an obligation, to take some action in the future related to real assets (Dixit & Pindyck, 1995). Growth opportunities characterize one type of real options.

2.2.2 The Black-Scholes Model

Black and Scholes (1973) claim that the simplest kind of option is a call option on a common stock. Based on this, the Black-Scholes model was developed for valuing financial call options. The model is partly based on the concept of Thorp and Kassouf (1967, ref.in Black & Scholes, 1973), who fit the best possible curve to observed warrant prices, and come up with a valuation formula for warrants. However, according to Black and Scholes (1973), Thorp and Kassouf (1967) fail to acknowledge that in equilibrium the expected return on a hedged position must be risk-free.

Based on this equilibrium condition, Black and Scholes (1973) derive the following theoretical model for valuing call options in terms of the stock price:

$$w(x,t) = xN(d_1) - ce^{r(t-t^*)}N(d_2)$$

$$d_1 = \frac{\ln\frac{x}{c} + \left(r + \frac{1}{2}v^2\right)(t^* - t)}{v\sqrt{t^* - t}}$$

$$d_2 = \frac{\ln\frac{x}{c} + \left(r - \frac{1}{2}v^2\right)(t^* - t)}{v\sqrt{t^* - t}}$$

where $w(x,t)$ denotes the option value as a function of stock price x and time t. The exercise price is given by c, r is the interest rate, t^* is the maturity date of the option, while v^2 denotes the variance rate. $N(d)$ represents the cumulative normal density function.

The Black-Scholes model requires that the market for stocks and options have "ideal" conditions. Black and Scholes (1973) therefore make assumptions including a known and constant short-term interest rate for borrowing, no transaction costs and that the option is a European option on a non-dividend paying stock, where the stock follows a random walk. If the market for stocks and options has "ideal" conditions, the option value only depends on the stock price, the time and various constants. In such a situation, it is possible to create a hedged position by going long in the stock and short in the option. Black and Scholes (1973) further argue that the value of the hedged position depends on the time and constants, but not on the stock price. The reason is that any change in value of the long position in the stock will be approximately offset by a corresponding change in value of the short position in the option. If this approximation were to be exact, one would have to continuously adjust the share of short positions in the option on the stock. Black and Scholes (1973) point out that if this were the case, the risk of the hedged position would be zero, giving an expected return on the hedged position equal to the short-term interest rate. Even if the short position in options is not continuously adjusted, they argue that with many hedged positions, potential risk can be diversified away. The hedged position therefore gives an expected return equal to a short-term interest rate. Thus, the change in value of the equity in the hedged position must be equal to the value of the equity in the hedged position times the short-term interest rate. With this equilibrium holding, the option value can be backed out.

2.2.3 The Replicating Portfolio

Cox, Ross and Rubinstein (1979) propose another approach for valuing call options. They show that the future returns of a call option can be replicated through taking positions in a stock using leverage. The value of a call option is therefore given by the following replicating portfolio:

$$C = S\Delta + B$$

where C is the value of the call option, S represents the current stock price, Δ denotes the number of shares in the stock and B is the amount of riskless bond.

Cox et al. (1979) also show that the replicating portfolio is closely related to the Black-Scholes model. They prove that the option delta, Δ, is equal to $N(d_1)$ and that the bond, B, is equal to $-\ ce^{r(t-t^*)}N(d_2)$ when the remaining number of periods until expiration goes to infinity.

3. Growth Options and Risk: Bernardo et al. (2007)

As mentioned in the introduction, our study is based on the framework of Bernardo et al. (2007). In Section 3.1, we present their framework for deriving a relation between growth options and the unlevered beta. The results of Bernardo et al. (2007) are presented in Section 3.2.

3.1 The Relation between Growth Options and the Unlevered Beta

Bernardo et al. (2007) consider a firm that has a growth option on its assets-in-place and assume that a firm's assets-in-place are described by the following geometric Brownian motion:

$$\frac{dA_t}{A_t} = \mu dt + \sigma dz_t$$

where A_t is the value of assets-in-place at time t, μ represents the expected growth rate of the return of assets-in-place, σ denotes the volatility of the return and z_t is a standard Wiener process, representing potential shocks.

They further assume that it is possible to create a replicating portfolio of the firm's assets-in-place and that the relation between the beta of growth options and beta of assets-in-place can be identified using the following version of the Black-Scholes model:

$$G_t = N(d_1)A_t - N(d_2)Ie^{-rT}$$

$$d_1 = \frac{\ln\frac{A_t}{Ie^{-rT}} + 0.5(\sigma\sqrt{T})^2}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

where G_t is the value of the firm's growth option at time t and I denotes the investment. The interest rate is represented by r, T is the maturity date and σ represents the standard deviation. $N(d)$ is the cumulative distribution function for the standard normal distribution.

It is straightforward to show that the relation between the beta of growth options and the beta of assets-in-place can be described by the following equation[1]:

$$\beta_t^G = \frac{\frac{dG_t}{dA_t}}{\frac{G_t}{A_t}} \beta_t^A$$

where β_t^G denotes the beta of growth options and β_t^A represents the beta of assets-in-place.

The above relation implies that $\beta_t^G > \beta_t^A$. This knowledge is important because it affects the cost of capital. Since the value of a firm consists of both the value of existing assets-in-place and the present value of growth options, the effect growth options has on the unlevered beta can be quantified by the weighted average of the beta of assets-in-place and the beta of growth options.

$$\beta_{i,t} = \frac{A_{i,t}}{V_{i,t}} \beta_{i,t}^A + (1 - \frac{A_{i,t}}{V_{i,t}}) \beta_{i,t}^G$$

where $\beta_{i,t}$ is the unlevered beta of firm *i* at time *t* and $A_{i,t}/V_{i,t}$ is the value of assets-in-place to total firm value.

In order to decompose the firm's unlevered beta, Bernardo et al. (2007) make two crucial assumptions. First, they assume that the value of assets-in-place to total firm value can be proxied by the book-to-market ratio. The book-to-market ratio is defined to be the sum of the book value of common equity and the book value of long-term outstanding debt, divided by the sum of the market value of equity and the book value of long-term outstanding debt. Secondly, they assume that the beta of assets-in-place and the beta of growth options are constant for all firms within an industry at any given time. Any within industry variation in the unlevered beta at a given time must therefore be due to different proportions of assets-in-place and growth options. To assume that there is no variation within an industry is most likely an approximation, but simplifies the analysis in a beneficial way.

[1] We provide an alternative derivation of this relation in Appendix A.1.

3.2 Empirical Findings

Bernardo et al. (2007) report estimates of average unlevered betas across industries over the time periods 2000-2004, 1995-2004 and 1977-2004, for 37 of the Fama-French 48-industry classifications. For each industry, they provide estimates of the mean unlevered beta and the average unlevered beta for firms with the 25^{th} (Q1) and the 75^{th} (Q3) percentile market-to-book, indicating average, below-average and above-average growth options, respectively. The estimates are listed in Table 1. Their results show that "in all periods and all industries, firms with above-average growth options (high market-to-book ratios) have higher unlevered betas than firms with below-average growth options (low market-to-book ratios)" (Bernardo et al., 2007, p. 11). The findings of higher unlevered betas for firm with above-average growth options indicate that the beta of growth options exceeds the beta of assets-in-place since the unlevered beta is a weighted average of these disentangled betas.

Table 1: Averages of Unlevered Betas by Bernardo et al. (2007)

Industry	2000-2004			1995-2004			1977-2004		
	Q1	Mean	Q3	Q1	Mean	Q3	Q1	Mean	Q3
Aircraft	--	--	--	0.537	0.621	0.702	0.852	0.954	1.051
Apparel	0.566	0.667	0.766	0.534	0.631	0.725	0.668	0.759	0.848
Automobiles/Trucks	0.580	0.674	0.766	0.567	0.699	0.830	0.714	0.838	0.960
Business Services	1.364	1.620	1.876	1.109	1.360	1.611	0.960	1.164	1.368
Business Supplies	0.469	0.490	0.511	0.510	0.548	0.586	0.642	0.715	0.786
Candy and Soda	--	--	--	--	--	--	0.863	1.068	1.265
Chemicals	0.561	0.601	0.640	0.589	0.643	0.697	0.709	0.819	0.927
Communication	0.886	1.133	1.379	0.837	1.020	1.201	0.696	0.925	1.149
Computers	1.430	1.608	1.785	1.256	1.429	1.601	1.223	1.356	1.488
Construction	0.588	0.651	0.713	0.516	0.636	0.754	0.708	0.845	0.980
Construction Materials	0.470	0.585	0.700	0.511	0.673	0.833	0.651	0.806	0.959
Consumer Goods	0.622	0.674	0.724	0.598	0.685	0.772	0.723	0.818	0.911
Electrical Equipment	1.302	1.447	1.591	1.099	1.298	1.495	0.971	1.132	1.291
Electronic Equipment	1.550	1.871	2.190	1.276	1.545	1.814	1.155	1.324	1.593
Entertainment	0.578	0.776	0.973	0.573	0.750	0.926	0.632	0.793	0.949
Fabricated Products	--	--	--	0.783	0.903	1.023	0.659	0.827	0.989
Food Products	0.345	0.331	0.317	0.427	0.459	0.491	0.546	0.597	0.648
Health Care	0.550	0.664	0.776	0.675	0.832	0.987	0.809	0.993	1.174
Machinery	0.663	0.834	1.004	0.694	0.853	1.011	0.736	0.882	1.028
Measuring/Control Eq.	1.372	1.478	1.583	1.115	1.267	1.417	0.993	1.152	1.310
Medical Equipment	0.774	0.926	1.077	0.825	1.000	1.173	0.918	1.069	1.218
Metal Mining	--	--	--	--	--	--	0.802	0.911	1.015
Personal Services	0.666	0.787	0.906	0.598	0.746	0.889	0.617	0.758	0.895
Petroleum/Natural Gas	0.506	0.610	0.712	0.495	0.604	0.712	0.616	0.734	0.852
Pharmaceutical Products	1.262	1.386	1.510	1.260	1.408	1.556	1.116	1.217	1.316
Precious Metals	--	--	--	0.300	0.401	0.500	0.336	0.336	0.337
Printing and Publishing	0.655	0.702	0.750	0.583	0.665	0.746	0.675	0.752	0.828
Recreational Products	0.626	0.795	0.958	0.603	0.762	0.917	0.734	0.853	0.969
Restaurants/Hotels/Motels	0.329	0.384	0.440	0.434	0.536	0.638	0.583	0.718	0.852
Retail	0.667	0.817	0.967	0.651	0.797	0.943	0.664	0.829	0.994
Rubber/Plastic Products	0.403	0.495	0.584	0.435	0.560	0.682	0.626	0.762	0.895
Shipping Containers	--	--	--	--	--	--	0.706	0.803	0.898
Steel Works Etc	0.573	0.754	0.932	0.595	0.758	0.918	0.661	0.791	0.918
Textiles	0.210	0.290	0.368	0.323	0.442	0.559	0.590	0.689	0.786
Transportation	0.422	0.549	0.674	0.457	0.628	0.798	0.539	0.695	0.849
Utilities	0.129	0.141	0.153	0.191	0.214	0.236	0.525	0.283	0.315
Wholesale	0.716	0.814	0.912	0.677	0.803	0.930	0.693	0.830	0.965

Bernardo et al. (2007) further provide the results from the disentangled betas. They find that over the whole sample period, the beta of growth options exceeds the beta of assets-in-place for all industries, except for Precious Metals. Bernardo et al. (2007) claim that their results are statistically significant for 34 of 37 industries at the 5 % level. Their results are reported in Table 2.

Based on their results, Bernardo et al. (2007) suggest certain rules of thumb with respect to capital budgeting and valuation. First, they emphasize that firms and projects with relatively more growth options should have a higher unlevered beta. Comparables should therefore be matched based on growth options. Second, they propose to compute three industry betas as displayed in Table 1. Projects and private firms can be assigned these betas according to their growth options, characterized as low, medium and high growth options. Thirdly, Bernardo et al. (2007) discourage firms from applying the overall firm beta in project valuation without considering the relative proportion of growth options and assets-in-place. Finally, Bernardo et al. (2007) argue that their results can be used to determine the beta of start-up firms, which usually do not have many appropriate comparables. By assuming that start-up firms do not have any assets-in-place, only growth options, they recommend that the beta of growth options in the industry should be applied when calculating the cost of capital.

Table 2: Averages of Asset and Growth Betas by Bernardo et al. (2007)

Industry	2000-2004			1995-2004			1977-2004		
	Asset	Growth	Diff	Asset	Growth	Diff	Asset	Growth	Diff
Aircraft	--	--	--	0.401	0.875	0.474	0.825	1.380	0.556
Apparel	0.537	0.906	0.369***	0.524	0.868	0.343***	0.687	1.011	0.324***
Automobiles/Trucks	0.582	0.956	0.374***	0.466	1.174	0.708***	0.742	1.298	0.557***
Business Services	1.129	2.055	0.926***	0.817	1.769	0.952***	0.820	1.564	0.744***
Business Supplies	0.480	0.550	0.070	0.501	0.667	0.166	0.665	1.022	0.357***
Candy and Soda	--	--	--	--	--	--	0.948	1.525	0.577***
Chemicals	0.541	0.716	0.1751	0.526	0.806	0.280**	0.663	1.228	0.565***
Communication	0.671	1.898	0.226*	0.587	1.565	0.978**	0.577	1.623	1.047***
Computers	1.194	1.953	0.759***	0.969	1.773	0.805***	1.088	1.676	0.588***
Construction	0.532	0.958	0.426	0.512	1.127	0.615***	0.758	1.387	0.629***
Construction Materials	0.451	0.837	0.385***	0.464	1.014	0.550***	0.694	1.262	0.568***
Consumer Goods	0.609	0.760	0.151	0.518	0.881	0.363*	0.671	1.100	0.430***
Electrical Equipment	0.964	1.809	0.845***	0.745	1.779	1.035***	0.824	1.546	0.722***
Electronic Equipment	1.255	2.496	1.241***	0.976	2.087	1.111***	1.036	1.739	0.703***
Entertainment	0.411	1.421	1.01***	0.445	1.305	0.860***	0.526	1.367	0.841***
Fabricated Products	--	--	--	0.655	1.571	0.916	0.856	1.571	0.715
Food Products	0.365	0.274	-0.091	0.420	0.505	0.085	0.545	0.731	0.186*
Health Care	0.284	0.991	0.707*	0.377	1.352	0.975***	0.577	1.672	1.095
Machinery	0.524	1.338	0.814***	0.537	1.340	0.803***	0.703	1.387	0.684***
Measuring/Control Eq.	1.183	1.722	0.539***	0.848	1.634	0.785***	0.862	1.607	0.745***
Medical Equipment	0.734	1.224	0.850***	0.442	1.333	0.891***	0.700	1.414	0.714***
Metal Mining	--	--	--	--	--	--	0.874	1.211	0.337
Personal Services	0.653	1.068	0.414***	0.554	1.103	0.550***	0.624	1.165	0.541***
Petroleum/Natural Gas	0.451	0.912	0.461***	0.393	0.972	0.579***	0.594	1.219	0.624***
Pharmaceutical Products	0.365	1.761	1.396	0.383	1.768	1.384***	0.701	1.492	0.792**
Precious Metals	--	--	--	0.383	0.737	0.355	0.433	0.375	-0.059
Printing and Publishing	0.562	0.819	0.256**	0.423	0.870	0.447*	0.579	0.975	0.396**
Recreational Products	0.604	1.190	0.586***	0.602	1.145	0.543***	0.767	1.165	0.397***
Restaurants/Hotels/Motels	0.315	0.538	0.223***	0.385	0.822	0.437**	0.537	1.196	0.659***
Retail	0.675	1.088	0.413***	0.633	1.092	0.459***	0.673	1.277	0.603***
Rubber/Plastic Products	0.372	0.802	0.430***	0.366	0.947	0.581***	0.626	1.160	0.533***
Shipping Containers	--	--	--	--	--	--	0.729	1.083	0.354
Steel Works Etc	0.553	1.357	0.803	0.61	1.300	0.690**	0.737	1.274	0.537***
Textiles	0.309	0.514	0.205***	0.359	0.847	0.488	0.677	1.090	0.412
Transportation	0.472	0.833	0.361***	0.432	1.204	0.772*	0.573	1.290	0.716***
Utilities	0.128	0.206	0.078	0.201	0.343	0.142**	0.309	0.583	0.274***
Wholesale	0.729	1.029	0.300***	0.664	1.095	0.431***	0.714	1.206	0.491***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4. Data

This section presents the data used in our thesis. Section 4.1 describes the databases and Section 4.2 presents the most important variables we include in our analysis. In Section 4.3, we describe the data cleaning procedure.

4.1 Databases

Our data are collected from the Wharton Research Data Services (WRDS) and the data library of Kenneth R. French. Access to the WRDS database is granted by the Department of Finance at NHH. We use data from the Center for Research in Security Prices (CRSP) merged with Compustat data. The CRSP is an extensive collection of security prices, return and volume data for the New York Stock Exchange (NYSE), American Stock Exchange (AMEX) and National Association of Securities Dealers Automated Quotations (NASDAQ), while the Compustat database includes fundamental accounting data. We also collect annual inflation rates and historical tax rates using the CRSP US Treasury and Inflation Indexes and the Compustat Marginal Tax Rates. From the public database of Kenneth R. French, we retrieve the monthly risk free rate and the monthly market risk premium.

4.2 Selected Variables

In the WRDS database, we need to specify which variables to include in our analysis. From the CRSP/Compustat Merged Fundamentals Annual, we include identifying information such as company name, company code and industry classification code [2]. From the firm's balance sheet, we include total assets, total liabilities and short- and long-term debt. In addition, the analysis requires information about the annual closing price and the number of shares outstanding by the end of each year. From the CRSP/Compustat Merged Security Monthly, we again select identifying information such as company name, company code and also a

[2] We use the Standard and Poor's identifier (GVKEY) as the company code and the Standard Industry Classification Code (SIC) to identify industries.

security identifier[3]. We also need information about each firm's total monthly return. For the remaining databases, no detailed specification of variables is necessary.

4.3 Data Cleaning Procedure

Our retrieved datasets comprise an extensive amount of data. Prior to any data cleaning, our datasets contain approximately 2.4 million observations. For the purpose of our analysis, we clean the data by leaving out observations that might cause a bias in our results. For this purpose, we follow the literature[4] and leave out stocks with a market capitalization of less than 100 million USD in real terms[5] and firms with a leverage ratio greater than one or less than zero[6]. To avoid a bias caused by outliers, we also drop observations with a negative book-to-market ratio and firms with an absolute value of the unlevered beta greater than 10. We also exclude some industries from our analysis[7], leaving us with a total of 37 industries. The decision to exclude these industries is based on the number of firms listed within each industry and industry characteristics like leverage ratio, the degree of regulations and how they are managed. Finally, for technical reasons, we only keep firms with calendar year-end annual accounting observations and firms listed for a consecutive time period of at least 60 months. We manually code the industries according to the Fama-French 48-industry classifications (Fama & French, 1997), and at last manually merge all datasets together. Once the data cleaning process is complete, we have a sample of approximately 350 000 observations covering over 2000 firms. The number of firms in each industry varies. However, all industries have at least 10 firms covered over the time period. This ensures that each industry has sufficient observations across the time period. The allocation of firms across industries is shown in Table 3 below.

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[3] We use the CUSIP as the security identifier.
[4] Suggested by e.g. Fama and French (1997, 2004) and Bernardo et al. (2007).
[5] We use 2010 as our base year. Market value of equity is equal to the number of shares outstanding in the end of each year times the fiscal annual closing price.
[6] The leverage ratio is calculated as total debt to total assets.
[7] Banking, Insurance, Real Estate, Trading, Utilities, Agriculture, Defense, Fabricated Products, Miscellaneous, Shipbuilding and Railroad Equipment and Tobacco Products.

Table 3: Allocation of Firms across Industries

Industry	1990-2013
	Number of firms
Aircraft	14
Alcoholic Beverages	10
Apparel	22
Automobiles/Trucks	42
Business Services	263
Business Supplies	51
Candy/Soda	12
Chemicals	73
Coal	10
Computers	74
Construction	20
Construction Materials	45
Consumer Goods	30
Electrical Eq.	17
Electronic Eq.	118
Entertainment	36
Food Products	31
Health Care	47
Machinery	71
Measuring/Control Eq.	35
Medical Eq.	70
Non-metallic Mining	22
Personal Services	18
Petroleum/Natural Gas	201
Pharmaceuticals	153
Precious Metals	34
Printing/Publishing	22
Recreational Products	12
Restaurants/Hotels/Motels	37
Retail	58
Rubber/Plastic Products	16
Shipping Containers	10
Steel Works	52
Telecommunications	173
Textiles	12
Transportation	113
Wholesale	64

5. Results and Analysis

In this section, we provide the results of our empirical work. In Section 5.1, we present the averages of unlevered betas for firms with above-average, medium and below-average growth options within each industry in the time periods 1995-2004, 2005-2013 and 1990-2013. We also present an alternative method for considering the relation between the unlevered beta estimates and the book-to-market ratios by using scatter plots. Section 5.2 includes detailed results obtained from performing the cross-sectional regression.

5.1 Unlevered Betas

Estimating the beta of assets-in-place and beta of growth options requires unlevered betas obtained from equity betas. Our estimation of equity betas is based on the commonly used CAPM, where the excess return[8] is regressed on the market risk premium. The equity beta is given by the slope coefficient of a rolling regression. We perform the rolling regression with a window of 60 consecutive months and robust standard errors. The following rolling regression is performed by industry (using the Fama-French 48-industry classifications), as a regression on the full sample of 350 000 observations takes over a week to complete:

$$r_{i,t} - {r_f}_t = \alpha_i + \beta_i MRP_t + \varepsilon_{i,t}$$

where $r_{i,t} - {r_f}_t$ denotes the monthly excess return of CUSIP[9] i at time t, α_i represents the intercept of the regression, β_i yield the equity beta and MRP_t is the market risk premium. $\varepsilon_{i,t}$ denotes the error term.

Once the equity betas are estimated, we keep all year-end beta observations and estimate unlevered betas using the formula for unlevering:

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

[8] Excess return is calculated as the monthly total return less the risk free rate.
[9] To avoid repeated time values within the panel, we estimate the beta of each CUSIP at time t. The rational is that a few firms have two listed CUSIPs.

where $\beta_{i,t}^{E}$ is the equity beta of the firm i at time t, τ is the tax rate and $D_{i,t}/E_{i,t}$ is the ratio of long-term debt to market value of equity. The tax rate is assumed to be 33 % over the entire sample period, and is obtained using an average of historical corporate tax rates in the U.S. in 1990-2013.

Table 4 reports estimates of average unlevered betas for 37 of the Fama-French 48-industry classifications over the time period 1990-2013 and the subsamples, 1995-2004 and 2005-2013. The average unlevered betas are listed for firms with above- and below-average growth options, in addition to medium growth options. Growth options are proxied by the book-to-market ratio, as this is perceived to be the most informative. The 25th (Q1) percentile book-to-market corresponds to firms with above-average growth options, while the 75th (Q3) percentile book-to-market denotes firms with below-average growth options. Consistent with the arguments made by Bernardo et al. (2007), the mean of unlevered betas can represent firms with medium growth options. When considering whether the highest unlevered beta is present with above-average growth options, we compare the 25th percentile book-to-market with the mean and the 75th percentile book-to-market.

Table 4: Average Unlevered Betas

Industry	1995-2004 Unlevered Beta			2005-2013 Unlevered Beta			1990-2013 Unlevered Beta		
	Q1	Mean	Q3	Q1	Mean	Q3	Q1	Mean	Q3
Aircraft	0.701	0.701	0.242	1.070	1.135	1.028	0.875	0.897	0.450
Alcoholic Beverages	--	--	--	--	--	--	0.592	0.498	0.588
Apparel	0.834	0.880	0.834	1.441	1.895	1.285	1.176	1.361	1.063
Automobiles/Trucks	0.867	0.716	0.372	1.515	1.002	1.019	1.092	0.598	0.573
Business Services	1.356	0.333	0.978	1.447	1.773	1.231	1.387	0.783	1.101
Business Supplies	0.643	0.497	0.615	0.853	0.596	0.711	0.789	0.746	0.676
Candy/Soda	0.888	0.533	0.578	0.610	0.968	0.529	0.731	0.845	0.569
Chemicals	0.728	0.376	0.489	1.008	0.978	1.138	0.903	0.974	0.765
Coal	--	--	--	--	--	--	0.787	0.907	0.729
Computers	1.598	0.889	1.283	1.655	1.897	1.357	1.545	1.469	1.255
Construction	0.836	1.182	0.537	1.639	1.475	0.928	1.495	1.395	0.690
Construction Materials	0.837	0.897	0.523	0.994	0.854	1.113	0.946	0.555	0.726
Consumer Goods	0.829	0.955	0.599	0.924	1.309	1.121	0.901	0.825	0.802
Electrical Eq.	0.960	0.823	0.646	1.628	2.173	1.206	1.212	1.179	0.985
Electronic Eq.	1.977	2.439	1.386	1.780	1.724	1.438	1.840	1.156	1.404
Entertainment	0.737	0.699	0.502	1.242	0.447	0.832	0.975	0.637	0.708
Food Products	0.301	0.641	0.364	0.381	0.540	0.950	0.424	0.340	0.685
Health Care	0.423	0.478	0.455	0.698	0.774	0.649	0.615	0.693	0.656
Machinery	1.173	0.497	0.660	1.356	1.111	1.329	1.264	0.497	0.935
Measuring/Control Eq.	1.371	1.174	1.307	1.387	1.069	1.515	1.353	2.115	1.394
Medical Eq.	1.132	0.714	0.683	0.831	1.051	1.031	1. 017	0.795	0.845
Non-metallic Mining	0.798	0.497	0.629	1.402	1.092	1.498	1.148	1.454	0.900
Personal Services	0.451	0.783	0.421	0.594	0.960	0.941	0.586	0.908	0.796
Petroleum/Natural Gas	0.751	1.208	0.570	0.988	0.865	1.053	0.839	0.663	0.751
Pharmaceuticals	1.148	0.753	1.131	1.090	0.298	0.912	1.102	0.706	0.964
Precious Metals	0.289	-0.089	0.417	0.811	0.682	0.504	0.472	0.394	0.367
Printing/Publishing	0.887	0.650	0.565	1.155	0.897	0.876	1.000	1.208	0.848
Recreational Products	0.480	0.193	1.037	--	--	--	0.729	1.135	1.025
Restaurants/Hotels/Motels	0.865	0.391	0.781	0.893	1.605	0.955	0.943	1.158	0.781
Retail	0.969	0.347	0.649	1.000	0.746	1.025	1.006	0.982	0.797
Rubber/Plastic Products	0.657	0.461	0.452	--	--	--	0.928	0.791	0.769
Shipping Containers	--	--	--	--	--	--	0.516	0.618	0.435
Steel Works	1.045	0.936	0.728	1.726	2.889	1.510	1.353	1.698	0.982
Telecommunications	0.921	0.744	0.823	1.278	1.417	0.783	1.084	1.029	0.788
Textiles	0.764	0.427	0.323	--	--	--	1.122	0.299	0.517
Transportation	0.834	0.280	0.523	0.907	0.481	0.761	0.903	0.193	0.655
Wholesale	0.669	0.630	0.716	0.887	0.312	1.053	0.803	1.106	0.764

When considering whether the average unlevered beta seems in fact greater for firms with above-average growth options, we address the full sample and the two subsamples. In the full sample, the majority of industries have the highest average unlevered beta for firms with above-average growth options (low book-to-market ratios). When considering the subsample of 1995-2004, we find similar results. In 2005-2013, however, only a few industries are observed to have the highest average unlevered beta when their growth options are characterized as above average. Thus, according to Table 4, our estimates do not indicate that firms with above-average growth options necessarily have the highest unlevered betas.

Comparing the subsamples, we find that there is no systematic pattern across industries and over the two time periods. As an example of this inconsistency, we can consider the Medical Equipment industry across the different subsamples. This industry has an unlevered beta of 1.132 for firms with above-average growth options in 1995-2004, while the unlevered beta of the mean and for firms with below-average growth options is 0.714 and 0.683, respectively. For this time period, it seems as if the unlevered beta is larger when firms experience above-average growth options, consistent with the arguments made by Bernardo et al. (2007). However, in 2005-2013, the same industry shows opposing values, where the average unlevered beta for firms with below-average growth options is 0.200 higher than the one for firms with above-average growth options. For the Food Products industry, the average unlevered beta for firms with above-average growth options is always lower than the one for firms with medium and below-average growth options in both subsamples. This is contradicting to the arguments made by Bernardo et al. (2007). Across all but 7 industries[10], Table 4 shows that the average unlevered betas are not consistently higher for firms with above-average growth options over the two subsamples. Consequently, the estimates of average unlevered betas do not give strong indications that more growth options relative to assets-in-place necessarily increase the unlevered beta.

An alternative method for graphically considering the relation between the unlevered beta estimates and growth options, proxied by the book-to-market ratio, is the use of scatter plots. We draw scatter plots of the unlevered beta estimates against the book-to-market ratios for each industry in the time-period 1990-2013. If high proportions of growth options relative to

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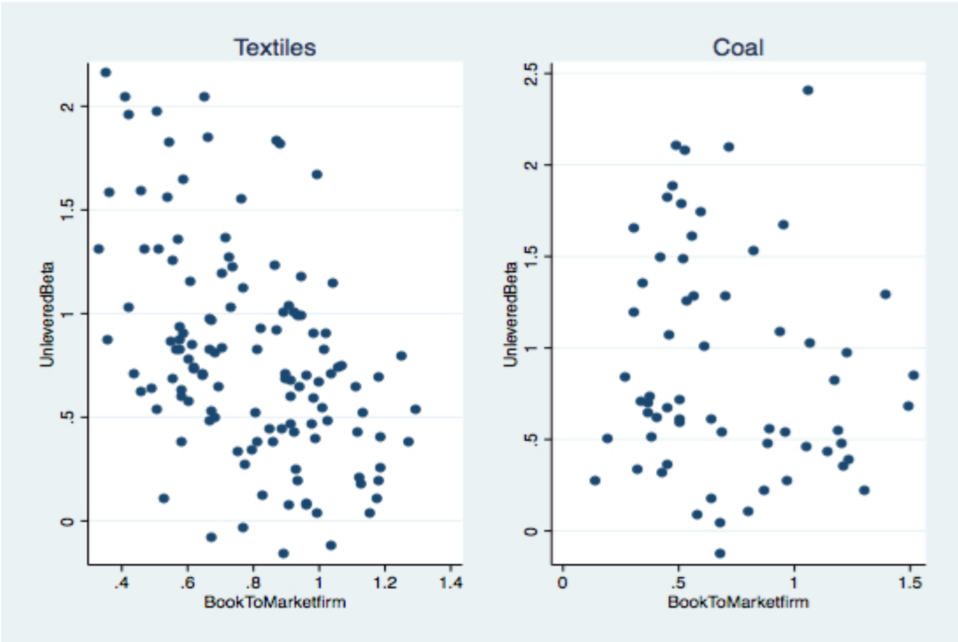
[10] Automobiles and Trucks, Business Supplies, Entertainment, Machinery, Pharmaceuticals, Printing and Publishing and Transportations.

assets-in-place are associated with high unlevered betas, we should expect to observe a declining pattern because a low book-to-market ratio implies high growth options.

Figure 1: Scatter Plots of Unlevered Beta against Firm Book-to-Market Ratio



The scatter plots in Figure 1 illustrates that the pattern of observations varies across industries. For the Textile industry, there seems to be a negative relation between the unlevered beta and the book-to-market ratio. A negative relation implies that the unlevered beta is high for low book-to-market ratios, i.e. high proportions of growth options. However, an equivalent negative relation is not the case for the Coal industry.

Figure 1 illustrates a tendency across our sample of industries, where no systematic negative relation between the unlevered beta and growth options is indicated. An important question of this thesis is whether the example of the Coal industry is “just an outlier” or whether there is no systematic empirical relation between unlevered betas and growth options. We address this issue in the next section using formal regression analysis, but note that scatter plots for the remaining industries are shown in Appendix A.2.

5.2 The Beta of Assets-in-Place and The Beta of Growth Options

Based on the framework presented in Section 3, we can derive the following relation between the unlevered beta and the disentangled betas:

$$\beta_{i,t} = \beta_t^G - (\beta_t^G - \beta_t^A)\frac{A_{i,t}}{V_{i,t}}$$

In order to estimate the beta of assets-in-place (asset beta) and the beta of growth options (growth beta), we apply the following cross-sectional regression[11] per industry:

$$\hat{\beta}_i = \beta^G + (\beta^A - \beta^G)\frac{A_i}{V_i} + \varepsilon_i$$

where ε_i represents the error term.

The regression coefficients are reported in Table 5. The intercept of the above regression is given by _cons, while the slope coefficient is represented by BtoM (book-to-market). Table 5 shows that the intercepts are statistically significant at the 5 % level for virtually all industries in all time-periods. The slope coefficients show different results regarding to the significance level and value.

[11] Accounting for firm fixed effects would imply losing the intercept. The intercept is crucial for the analysis, which is why we perform a regular OLS regression.

Table 5: Regression Coefficients

Industry	1995-2004		2005-2013		1990-2013	
	_cons	BtoM	_cons	BtoM	_cons	BtoM
Aircraft	0.910***	-0.564***	1.069***	0.007	1.128***	-0.540***
Alcoholic Beverages	--	--	--	--	0.709***	-0.089
Apparel	0.998***	-0.257	1.383***	-0.206	1.159***	-0.159
Automobiles/Trucks	0.974***	-0.484***	1.584***	-0.500**	1.200***	-0.500***
Business Services	1.404***	-0.411***	1.419***	-0.187*	1.386***	-0.271***
Business Supplies	0.555***	0.042	1.063***	-0.241	0.814***	-0.105*
Candy/Soda	0.895***	-0.465	0.887***	-0.326	0.915***	-0.427***
Chemicals	0.789***	-0.247***	1.108***	0.031	0.998***	-0.220***
Coal	--	--	--	--	1.039***	-0.218
Computers	1.762***	-0.488*	1.690***	-0.297***	1.691***	-0.389***
Construction	0.975***	-0.265*	1.908***	-0.787***	1.651***	-0.693***
Construction Materials	0.940***	-0.426***	1.013***	0.086	0.982***	-0.219***
Consumer Goods	0.912***	-0.274**	0.972***	0.100	0.892***	-0.018
Electrical Eq.	1.066***	-0.692**	1.654***	-0.638	1.255***	-0.471*
Electronic Eq.	1.993***	-0.592***	1.834***	-0.295***	1.856***	-0.411***
Entertainment	0.888***	-0.380***	1.260***	-0.370	1.045***	-0.323**
Food Products	0.329***	0.109	0.276***	0.739***	0.450***	0.274***
Health Care	0.541***	-0.069	0.637***	0.027	0.616***	0.010
Machinery	1.300***	-0.710***	1.370***	-0.035	1.355***	-0.439***
Measuring/Control Eq.	1.327***	-0.300	1.264***	0.195	1.231***	0.105
Medical Eq.	1.079***	-0.584***	0.745***	0.326**	0.929***	-0.075
Non-metallic Mining	0.797***	-0.141	1.320***	0.201	1.222***	-0.296**
Personal Services	0.691***	-0.193	0.712***	0.223*	0.739***	0.051
Petroleum/Natural Gas	0.863***	-0.338***	0.951***	0.082	0.837***	-0.097*
Pharmaceuticals	1.053***	0.011	0.966***	-0.074	1.041***	-0.115
Precious Metals	0.303***	0.137	0.811***	-0.297**	0.450***	-0.083
Printing/Publishing	0.801***	-0.292**	1.292***	-0.470	0.948***	-0.231*
Recreational Products	0.411*	0.576	--	--	0.811***	0.215
Restaurants/Hotels/Motels	0.682***	0.044	0.893***	0.070	0.905***	-0.107
Retail	0.992***	-0.318**	1.063***	0.026	1.047***	-0.191**
Rubber/Plastic Products	0.465***	0.083	--	--	0.775***	-0.003
Shipping Containers	--	--	--	--	0.647***	-0.220*
Steel Works	1.092***	-0.271***	1.712***	-0.194	1.395***	-0.349***
Telecommunications	1.000***	-0.174*	1.353***	-0.555***	1.158***	-0.369***
Textiles	1.164***	-0.815***	--	--	1.621***	-1.042***
Transportation	0.934***	-0.400***	0.885***	-0.069	0.915***	-0.198***
Wholesale	0.684***	-0.013	0.840***	0.180	0.854***	-0.082

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

According to the cross-sectional regression model above, the intercept (_cons) yields the growth beta, while the slope coefficient (BtoM) provides the difference between the asset beta and growth beta. Based on the regression coefficients given in Table 5, the asset betas can be backed out.

The results of the disentangled betas provide useful implications for capital budgeting and valuation exercises. First, private firms and project managers can use our results to determine the importance of matching their growth options with the ones of the comparables. Second, the results can be used to determine the unlevered beta for start-up firms and mature firms with no growth options as discussed by Bernardo et al. (2007). They argue that it is possible to consider start-up firms as firms with no assets-in-place, only growth options. If we assume that start-up firms do not fundamentally differ from public firms, the average growth beta in the industry can be assigned as their unlevered beta. Mature firms, on the other hand, can apply the average asset beta in the industry. Finally, we can consider how the unlevered beta is affected if the amount of growth options relative to assets-in-place in a firm or project change. A negative difference between the asset beta and the growth beta will result in a decreased unlevered beta if the value of assets-in-place to total firm value increase. In other words, less growth options relative to assets-in-place will decrease the unlevered beta. Thus, for a positive difference, more growth options will decrease the unlevered beta.

Table 6 provides estimates of the asset beta (Asset), growth beta (Growth) and difference between the asset beta and growth beta (Diff) across industries in the time period 1990-2013. In addition, the number of observations in each industry (N) and the adjusted R^2 (R-Sq) are reported. The adjusted R^2 measures the percentage of the variation in the dependent variable that is explained by the independent variable adjusted for the degrees of freedom. A statistically significant difference between the asset beta and the growth beta implies that we can reject the null hypothesis that the difference between the two disentangled betas are equal to zero. Thus, we are able to provide an economic interpretation.

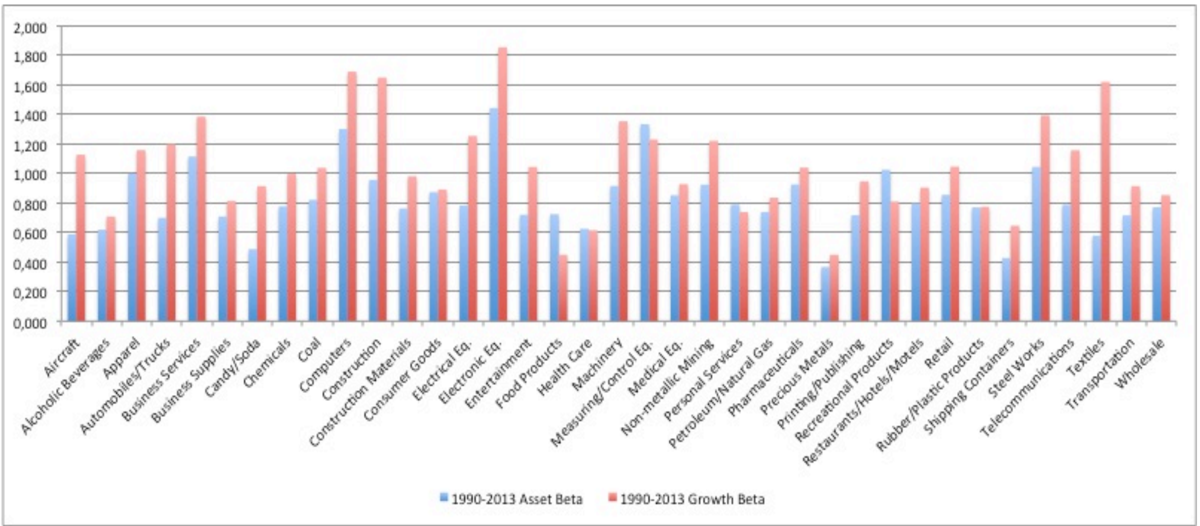
Table 6: Average Asset Betas, Growth Betas and Differences in 1990-2013

Industry	1990-2013				
	Asset	Growth	Diff	N	R-Sq
Aircraft	0.588	1.128	-0.540***	214	0.152
Alcoholic Beverages	0.620	0.709	-0.089	137	0.005
Apparel	1.000	1.159	-0.159	220	0.008
Automobiles/Trucks	0.700	1.200	-0.500***	478	0.134
Business Services	1.116	1.386	-0.271***	2079	0.012
Business Supplies	0.709	0.814	-0.105*	597	0.008
Candy/Soda	0.488	0.915	-0.427***	158	0.066
Chemicals	0.778	0.998	-0.220***	790	0.019
Coal	0.822	1.039	-0.218	63	0.016
Computers	1.302	1.691	-0.389***	564	0.026
Construction	0.957	1.651	-0.693***	159	0.163
Construction Materials	0.764	0.982	-0.219***	533	0.022
Consumer Goods	0.874	0.892	-0.018	431	0.000
Electrical Eq.	0.784	1.255	-0.471*	216	0.025
Electronic Eq.	1.444	1.856	-0.411***	1151	0.030
Entertainment	0.721	1.045	-0.323**	288	0.026
Food Products	0.725	0.450	0.274***	297	0.045
Health Care	0.626	0.616	0.010	342	0.000
Machinery	0.916	1.355	-0.439***	956	0.039
Measuring/Control Eq.	1.335	1.231	0.105	446	0.002
Medical Eq.	0.853	0.929	-0.075	526	0.002
Non-metallic Mining	0.925	1.222	-0.296**	213	0.026
Personal Services	0.790	0.739	0.051	163	0.003
Petroleum/Natural Gas	0.740	0.837	-0.097*	1870	0.004
Pharmaceuticals	0.926	1.041	-0.115	1221	0.002
Precious Metals	0.367	0.450	-0.083	285	0.003
Printing/Publishing	0.718	0.948	-0.231*	240	0.025
Recreational Products	1.026	0.811	0.215	110	0.018
Restaurants/Hotels/Motels	0.798	0.905	-0.107	352	0.007
Retail	0.856	1.047	-0.191**	531	0.014
Rubber/Plastic Products	0.771	0.775	-0.003	186	0.000
Shipping Containers	0.428	0.647	-0.220*	128	0.040
Steel Works	1.045	1.395	-0.349***	551	0.045
Telecommunications	0.789	1.158	-0.369***	1297	0.043
Textiles	0.579	1.621	-1.042***	124	0.221
Transportation	0.717	0.915	-0.198***	1055	0.031
Wholesale	0.772	0.854	-0.082	585	0.003

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Our results show that the difference between the disentangled betas is negative and statistically significant at the 5 % level for only 17 out of 37 industries. This implies that we can reject the null hypothesis of a difference equal to zero for these 17 industries. These findings are therefore consistent with previous research claiming that the growth beta exceeds the asset beta. Table 6 also displays results that are contradicting to previous research. The Food Products industry is the only industry with a positive difference that is statistically significant at the 5 % level. This implies that the asset beta exceeds the growth beta. For the remaining industries, we cannot conclude whether the growth beta differs from the asset beta, due to insignificant differences between the disentangled betas. The results of Table 6 are graphically illustrated in Figure 2.

Figure 2: Average Asset and Growth Betas across Industries in 1990-2013



Our results can be used to determine the practical importance for private firms and projects of matching their growth options with the ones of comparables. For the industries with statistically significant differences between asset betas and growth betas of a certain magnitude, firm and project valuation will become more accurate if growth options are matched. As an illustration, we can consider the Textiles industry, which represents an industry where it is crucial to consider growth options when determining comparables. The difference between the asset beta and growth beta is as high as -1.042, and statistically significant at the 5 % level. Private firms and project managers within the Textiles industry risk making wrong valuations and investment decisions if they do not select comparables based on their growth options.

If the difference between the asset beta and growth beta is instead trivial, but still statistically significant, it is not crucial to match growth options since the unlevered beta is a weighted average of the disentangled betas. The reason is that even though the private firm or project has different proportions of growth options and assets-in-place relative to the firms used as comparables, the unlevered beta would not be substantially affected by neglecting the impact of growth options. The Retail industry represents the industry with the smallest difference being statistically significant at the 5 % level. With a difference of -0.191, it is evident that accounting for growth options has an impact on the unlevered beta, but the effect is less crucial than for the Textiles industry. Finally, as previously mentioned, for those industries where the difference between the disentangled betas are statistically insignificant, we cannot conclude whether accounting for growth options is important when assessing the appropriate unlevered beta. For as many as 19 industries, the difference between the disentangled betas is insignificant. It is worth noticing that these industries seem to have sufficient observations. Based on our results, we can therefore not claim that accounting for growth options in the decision of comparables is necessarily crucial for all industries.

As suggested by Bernardo et al. (2007), start-up firms and mature firms with no growth can apply our results in order to determine their unlevered beta. Assuming a market risk premium of 5 %, our estimates in the Textiles industry could result in a cost of capital difference of 5.21 % between the start-up firm and mature firm when using the industry as a comparable. In the Retail industry, however, there will be a cost of capital difference between a start-up and mature firm, but compared with the Textiles industry it will be considerably smaller. According to our results, a start-up firm should apply a cost of capital that is 0.96 % greater than the one of a mature firm in this industry. The Food Products industry stands out as the only industry where the difference between asset beta and growth beta is positive and statistically significant. Assuming 5 % market risk premium, the difference of 0.274 implies that the cost of capital for a mature firm with no growth can exceed the cost of capital of a start-up firm by 1.37 % using the industry as a comparable. Given that our results also contain several insignificant differences, we therefore show that the appropriate unlevered beta of start-up firms should not necessarily exceed the one of mature firms.

Finally, we can consider that a firm changes their proportion of growth options relative to assets-in-place. If the value of assets-in-place to total firm value increases by one unit in the Textiles industry so that the proportion of growth options declines, the unlevered beta will decrease by 1.042. If growth options increase, however, the unlevered beta will become 1.042 higher per unit decrease in the value of assets-in-place to total firm value. The high adjusted R^2 of 0.221 for the Textile industry indicates that the unlevered beta is in fact influenced by growth options. More specifically, the adjusted R^2 implies that 22.1 % of the variation in the unlevered beta is explained by the book-to-market ratio. In the Retail industry, the corresponding changes in the proportion of growth options to assets-in-place will cause the unlevered beta to decrease (increase) by 0.191. It is, however, worth noticing that the adjusted R^2 for this industry is low. In the Food Products industry, where the difference is positive, the unlevered beta will increase by 0.274 if the value of assets-in-place to the total firm value increases by one unit. This means that less growth options relative to assets-in-place increase the unlevered beta. The adjusted R^2 for the Food Products industry is, however, only 0.045. Consequently, a change in the proportions of growth options and assets-in-place should not necessarily imply that more growth options yield a higher unlevered beta.

Table 7 provides the average estimates of the asset beta, growth beta and the difference between them across industries in the subsamples 1995-2004 and 2005-2013. In 1995-2004, the difference is negative and statistically significant at the 5 % level for only 17 out of the 34 industries with sufficient observations. None of the positive differences are statistically significant. In 2005-2013, the respective numbers are only 6 and 2 out of 31 industries. The subsamples therefore underline that accounting for growth options in estimating the unlevered beta by the use of comparables is important for some industries, while not for others.

Table 7: Average Asset Betas, Growth Betas and Differences in 1995-2004 and 2005-2013

Industry	1995-2004					2005-2013				
	Asset	Growth	Diff	N	R-Sq	Asset	Growth	Diff	N	R-Sq
Aircraft	0.345	0.910	-0.564***	88	0.253	1.076	1.069	0.007	74	0.000
Alcoholic Beverages	--	--	--	--	--	--	--	--	--	--
Apparel	0.741	0.998	-0.257	98	0.015	1.178	1.383	-0.206	86	0.021
Automobiles/Trucks	0.490	0.974	-0.484***	229	0.267	1.084	1.584	-0.500**	147	0.103
Business Services	0.993	1.404	-0.411***	840	0.022	1.232	1.419	-0.187*	1036	0.007
Business Supplies	0.597	0.555	0.042	283	0.002	0.823	1.063	-0.241	166	0.024
Candy/Soda	0.430	0.895	-0.465	62	0.057	0.560	0.887	-0.326	77	0.031
Chemicals	0.541	0.789	-0.247***	346	0.056	1.139	1.108	0.031	291	0.000
Coal	--	--	--	--	--	--	--	--	--	--
Computers	1.274	1.762	-0.488*	241	0.020	1.393	1.690	-0.297***	227	0.019
Construction	0.710	0.975	-0.265*	51	0.056	1.120	1.908	-0.787***	98	0.166
Construction Materials	0.514	0.940	-0.426***	237	0.088	1.099	1.013	0.086	178	0.003
Consumer Goods	0.638	0.912	-0.274**	208	0.038	1.072	0.972	0.100	142	0.012
Electrical Eq.	0.374	1.066	-0.692**	88	0.070	1.016	1.654	-0.638	90	0.053
Electronic Eq.	1.402	1.993	-0.592***	430	0.037	1.539	1.834	-0.295***	606	0.021
Entertainment	0.508	0.888	-0.380***	118	0.075	0.890	1.260	-0.370	136	0.025
Food Products	0.438	0.329	0.109	106	0.012	1.015	0.276	0.739***	130	0.198
Health Care	0.473	0.541	-0.069	138	0.003	0.663	0.637	0.027	178	0.000
Machinery	0.590	1.300	-0.710***	417	0.107	1.336	1.370	-0.035	397	0.000
Measuring/Control Eq.	1.027	1.327	-0.300	164	0.007	1.459	1.264	0.195	232	0.006
Medical Eq.	0.495	1.079	-0.584***	210	0.053	1.071	0.745	0.326**	248	0.041
Non-metallic Mining	0.656	0.797	-0.141	84	0.021	1.521	1.320	0.201	95	0.009
Personal Services	0.499	0.691	-0.193	57	0.053	0.936	0.712	0.223*	78	0.054
Petroleum/Natural Gas	0.525	0.863	-0.338***	766	0.052	1.033	0.951	0.082	793	0.003
Pharmaceuticals	1.063	1.053	0.011	513	0.000	0.892	0.966	-0.074	573	0.001
Precious Metals	0.440	0.303	0.137	108	0.009	0.514	0.811	-0.297**	112	0.053
Printing/Publishing	0.508	0.801	-0.292**	119	0.064	0.822	1.292	-0.470	50	0.068
Recreational Products	0.986	0.411	0.576	46	0.089	--	--	--	--	--
Restaurants/Hotels/Motels	0.725	0.682	0.044	164	0.002	0.963	0.893	0.070	135	0.002
Retail	0.674	0.992	-0.318**	244	0.044	1.089	1.063	0.026	214	0.000
Rubber/Plastic Products	0.548	0.465	0.083	78	0.031	--	--	--	--	--
Shipping Containers	--	--	--	--	--	--	--	--	--	--
Steel Works	0.821	1.092	-0.271***	250	0.066	1.518	1.712	-0.194	196	0.012
Telecommunications	0.827	1.000	-0.174*	520	0.011	0.798	1.353	-0.555***	551	0.074
Textiles	0.349	1.164	-0.815***	68	0.304	--	--	--	--	--
Transportation	0.535	0.934	-0.400***	402	0.104	0.817	0.885	-0.069	492	0.005
Wholesale	0.671	0.684	-0.013	267	0.000	1.020	0.840	0.180	236	0.012

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As Table 7 shows, the subsamples indicate some industries where accounting for growth options is particularly important, but the picture changes between the time periods. In 1995-2004, the growth beta is substantially greater than the asset beta for e.g. the Electrical Equipment, Machinery and Textiles industry. The Machinery industry displays a negative difference of 0.710, statistically significant at the 5 % level. To illustrate the impact growth options have on the unlevered beta in this industry, we consider two firms, one private and one public, with different proportions of growth options relative to assets-in-place. We assume that the publicly listed firm consists of fourth-fifths growth options and one-fifths assets-in-place, while the private firm has the opposite structure. According to Table 7, the publicly listed firm will have an unlevered beta equal to 1.158[12]. If the private firm uses the public firm as a comparable and we assume a market risk premium of 5 %, they will overestimate their cost of capital by 2.13 % due to different proportions of growth options and assets-in-place. This illustration therefore shows that accounting for growth options is important for firms in industries where the difference between asset and growth beta is substantial and statistically significant. The reason is that private firms and project managers risk a serious cost of capital error if the proportions of growth options and assets-in-place differ between the comparable and private firm or project. In 2005-2013, the difference between asset beta and growth beta is substantial for e.g. the Construction and Food Products industry. Compared to 1995-2004, the difference in the Electrical Equipment industry is of the same magnitude, but is statistically insignificant. For the Machinery industry, the difference dramatically declines to -0.035 and becomes statistically insignificant. The Textiles industry has insufficient observations in 2005-2013.

None of the trivial differences displayed in Table 7 are statistically significant at the 5 % level. We can, however, consider an example where the effect growth options has on the unlevered beta is less severe compared to the Machinery industry mentioned above. By applying the previous illustration with a private and public firm on the Chemicals industry in 1995-2004, the private firm will overestimate their cost of capital by 0.74 %. It is therefore clear that firms in the Chemicals industry will be affected to a lesser extent than firms in the Machinery industry by not considering their growth options relative to the comparables. However, if the investment or value is large enough, a 0.74 % cost of capital error may still

[12] Given the assumption of constant asset and growth beta within an industry.

yield serious consequences. In 2005-2013, the difference between the asset beta and growth beta becomes insignificant for the Chemicals industry.

Comparing results across the two subsamples, we only find one industry where the difference is statistically significant and of similar size in both time periods. This applies to the Automobiles and Trucks industry where the difference is consistently statistically significant and close to -0.500. The adjusted R^2 shows that 26.7 % and 10.3 % of the variance in the unlevered beta is explained by the book-to-market ratio in the respective time periods. In addition, the Electronic Equipment and Medical Equipment industry have a difference that is statistically significant at the 5 % level in both periods. However, the size of the differences for the respective industries varies from -0.592 to -0.295 and from -0.584 to 0.326 across the time periods. Our results indicate that it will be of importance for firms in these industries to account for growth options in assessing future risk measures. A considerable number of industries have a difference between the asset beta and growth beta that is consistently insignificant. For 10 industries[13], we cannot conclude that the difference is statistically different from zero. For the remaining industries, the results are inconclusive with respect to significance level across the subsamples. This implies that it is difficult to determine whether it will be of importance for firms in these industries to account for growth options in future risk estimation. It may, however, be relevant to focus the attention on the latest time period.

In 2005-2013, we experience that fewer industries have a significant difference between asset beta and growth beta than in 1995-2004. The difference is insignificant for 23 out of 31 industries. The corresponding number in 1995-2004 is 17 out of 34 industries. Thus, for the majority of industries in 2005-2013, we cannot conclude that the difference between asset beta and growth beta is statistically different from zero. The disentangled betas are also generally greater in 2005-2013 than in 1995-2004. The latest financial crisis hit the markets hard in 2008. Thus, a large part of the period 2005-2013 is influenced by this global economic downturn, which caused markets to become more volatile. This may be one reason why our beta estimates are generally greater in this period, and should be kept in mind when applying our results.

[13] Apparel, Business Supplies, Candy and Soda, Health Care, Measuring and Control Equipment, Non-metallic Mining, Personal Services, Pharmaceuticals, Restaurants/Hotels/Motels and Wholesale.

6. Conclusion

The purpose of our study is to empirically analyse the effect growth options have on the unlevered beta. Previous research claims that growth options generally increase the risk of firms. We therefore propose a hypothesis that the growth beta exceeds the asset beta and that the unlevered beta thereby increases with growth options. Our analysis includes firms listed on NYSE, AMEX and NASDAQ over the period 1990-2013. We proxy growth options using the book-to-market ratio and apply a cross-sectional regression where we regress the unlevered betas on the book-to-market ratios. The slope and intercept of the regression line yields the growth beta and the difference between asset beta and growth beta.

Our results show that the effect growth options have on the unlevered beta varies across industries and time periods. We observe both some significant and insignificant results, and the effect growth options have on unlevered beta may be positive or negative depending on the industry. Although we can reject the null hypothesis that the difference between the growth beta and asset beta is equal to zero for some industries, we show that the same rule of thumb cannot be applied across all industries as previously suggested by, for instance, Bernardo et al. (2007).

With regards to previous research claiming that growth options increase the risk of firms, we do not completely disagree. However, our results shed new light by suggesting that the growth beta does not necessarily exceed the asset beta. Consequently, more growth options relative to assets-in-place do not always cause the unlevered beta to increase.

In the time period 1990-2013, our results show that the importance of accounting for growth options in estimation of the unlevered beta varies substantially across industries. Our postulated hypothesis claiming that the growth beta exceeds the asset beta applies to only 17 out of 37 industries at the 5 % significance level. The size of the differences between the disentangled betas varies from -0.191 to -1.042. This implies that even though the difference is statistically significant, the cost efficiency of accounting for growth options when determining comparables differs among industries. However, neglecting the impact growth options have on the unlevered beta may result in decisions with severe consequences.

Ultimately, this may destroy firm value. For 19 industries, we cannot conclude that the growth beta differs from the asset beta in a statistically significant matter.

Looking closer at two subsamples, 1995-2004 and 2005-2013, we find that only the Automobiles and Trucks industry has a difference similar in size and statistically significant in both time periods. In addition, the Electronic Equipment and Medical Equipment industry have a difference that is statistically significant at the 5 % level, but varying in size, in both periods. The results can be applied for predictive purposes by private firms and project managers in these industries. The subsamples also reveal that 10 industries[14] have a consistently insignificant difference. For the remaining industries, we find the significance level to be inconclusive across the subsamples. This emphasizes that the growth beta does not necessarily exceed the asset beta, implying that more growth options relative to assets-in-place do not always increase the unlevered beta.

Since our results are contradicting to previous studies, we recommend further research on this area. Considering different stock markets may provide additional insight on the effect growth options have on the unlevered beta. Further research may also be conducted to examine whether the book-to-market ratio is, in fact, the best proxy for growth options.

[14] Apparel, Business Supplies, Candy and Soda, Health Care, Measuring and Control Equipment, Non-metallic Mining, Personal Services, Pharmaceuticals, Restaurants/Hotels/Motels and Wholesale.

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8. Appendix

A.1 Deriving the Relation Between the Growth Beta and Asset Beta

Growth options can be valued using the replicating portfolio:

$G_t = A_t\Delta + B$
where Δ is the amount of assets-in-place and B is the amount of riskless bond.

Since the replicating portfolio consists of both assets-in-place and a riskless bond, the beta of growth options is a weighted average of the beta of the assets-in-place, β_t^A, and the beta of the bond, β^B.

$$\beta_t^G = \frac{A_t\Delta}{A_t\Delta + B}\beta_t^A + \frac{B}{A_t\Delta + B}\beta^B$$

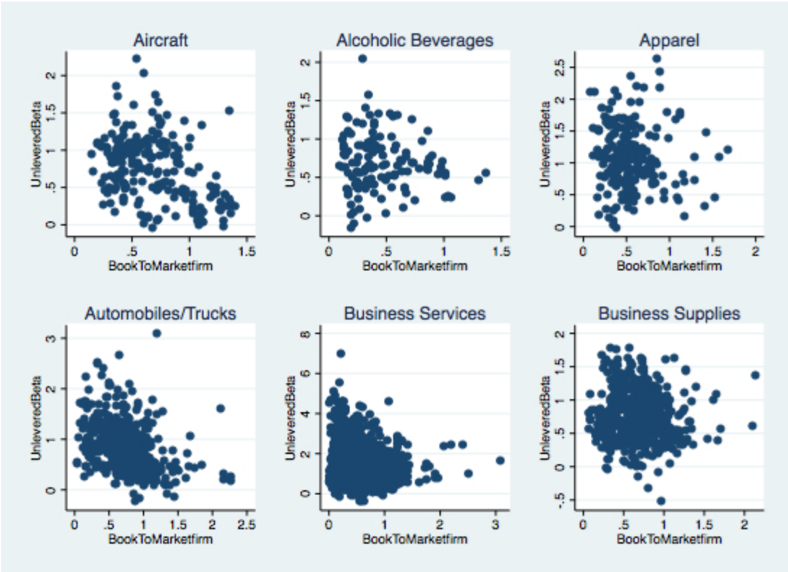
Because the bond is riskless and since beta represents a measure of risk, the beta of the bond must be equal to zero. This results in the following relation:

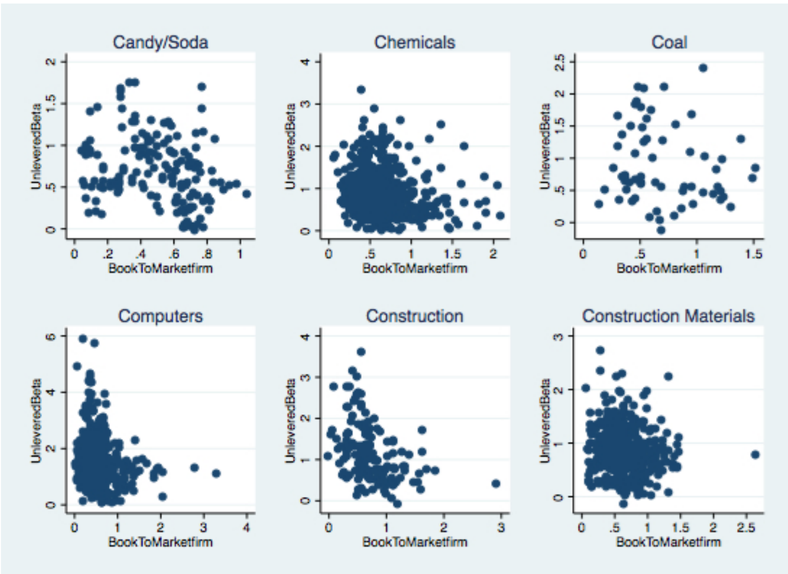
$$\beta_t^G = \frac{A_t\Delta}{A_t\Delta + B}\beta_t^A$$

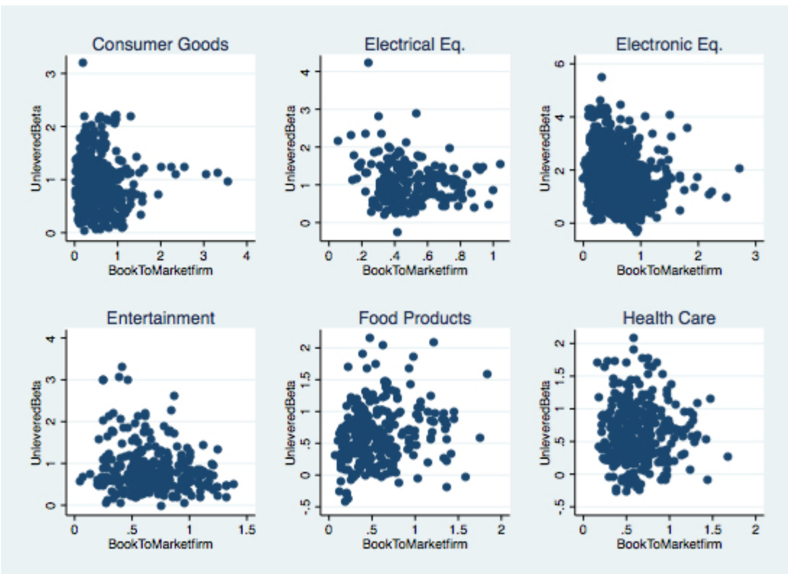
It is well known in the financial literature that $\Delta = N(d_1)$. It is also straightforward to show that $N(d_1) = dG_t/dA_t$ and that $G_t < A_t\Delta$ since B is negative. The above relation can therefore be rewritten in the following way:

$$\beta_t^G = \frac{\frac{dG_t}{dA_t}}{\frac{G_t}{A_t}}\beta_t^A$$

A.2 Scatter Plots of Unlevered Beta against Book-to-Market Ratio





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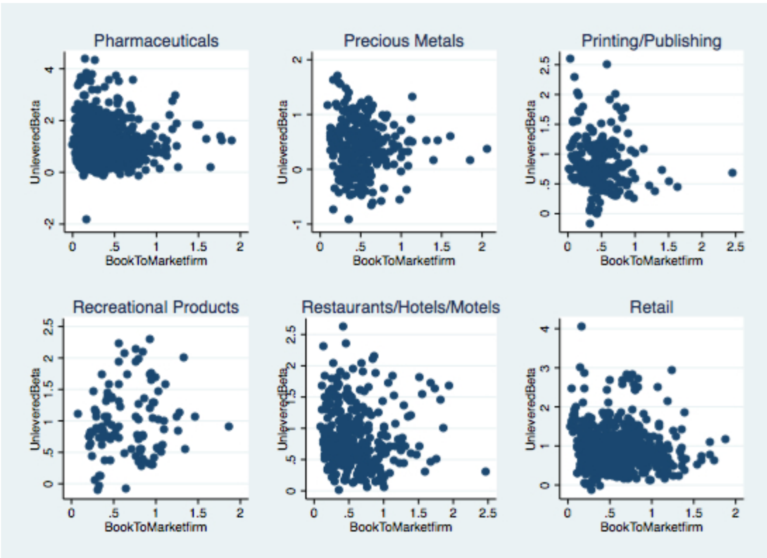
Measuring/Control Eq.
Medical Eq.
Non-metallic Mining
Personal Services
Petroleum/Natural Gas
UnleveredBeta
BookToMarketfirm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Precious Metals
Printing/Publishing
Recreational Products
Restaurants/Hotels/Motels
Retail
UnleveredBeta
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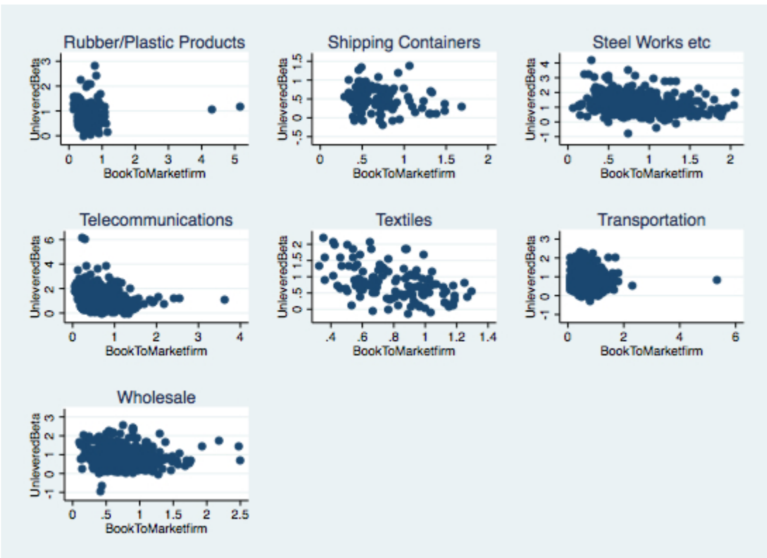
Rubber/Plastic Products
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