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Applying black- Scholes model to breakdown beta: growth options and the risk of beta miscalculation

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Abstract

When evaluating companies and investment plans, most analysts use a discount rate that is derived from CAPM models. The beta in these models usually represent risks and opportunities of the relative industry, with almost no attention to the risks that are already included in the beta. This ignorance in risk measurement could ultimately impair shareholders value. What makes things critical is that by adjusting risks and opportunities in beta, the result of investment plans and company valuation could be much different. In this paper we use 1 to 10 years of monthly return data for all industries of Tehran Stock Exchange and Iran Fara Bourse and suggest an adjusted beta for each industry which is stripped of the dazzling effects of the debts and growth opportunities. We separately account for breaking down beta into beta of growth opportunities and beta of existing assets for each industry in various timelines between 1 to 10 years. Our results showed that the beta of growth opportunities is bigger than the beta of assets for almost all industries. The mentioned betas can make a big difference in cost of capital and we suggest using them when evaluating investment plans, development plans, valuation of companies and even start-ups.

Keywords: Systematic Risk, Growth Opportunities, Evaluation, Beta.

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Introduction

After all these years, Capital asset pricing Model (CAPM) has outperformed all the other methods and models in determining cost of capital despite arguments against it. In Practice, CAPM is still the most popular method, for other models' factors are unstable over time and disagreements about them continue to persist (Fama & French, 1992). Some of the other models suggest factors that are hard to measure. On the other hand, CAPM is estimated with only three Items: Risk Free rate, Risk Premium and the asset's beta.

One of the obstacles of CAPM model is when estimating beta of investment projects. Since these projects are not necessarily tradable, they do not have observable beta. Standard textbooks suggest measuring beta from a set of comparable traded securities (e.g. (Brealey, Myers, & Allen, 2006)). But the problem is that most of the time, growth opportunities of the investment project is completely different from the selected set of securities. Even a small miscalculation of beta can lead to a completely different discount rate and change the result of economic evaluation of any project.

The mentioned bias is the main problem we address in this paper. We show that growth opportunity is a very important factor of the firm's beta and if one fails to recognize this factor correctly, it can lead to a misinterpretation of the cost of equity. Hence, we provide an alternative model which measures the beta of growth opportunities and existing assets.

There are reasons to believe that companies with greater opportunities have greater betas. First of all, Brealey, Myers and Allen showed that betas are largely attributable to variation in expected returns (Brealey, Myers, & Allen, 2006). Because Duration of Companies with more growth opportunities is longer, it is more likely that interest rate changes affect their values, which leads to higher betas (Cornell, 1999), (Dechow, Sloan, & Soliman, 2004).

Second, aside from explicit meaning, growth opportunities always have embedded options (for instance option to leave, expand or delay a project) and so, it has a systematic risk component. Because the mentioned options have implicit leverage, the systematic risk of growth opportunities should be higher than assets that are already in place ((Berk, Green, & Naik, Valuation and Return Dynamics of New Ventures, 2004), (Carlson, Fisher, & giammarino, 2004), (Carlson, Fisher, & Giammarino, 2006)).

Our purpose is to show a link between a firm's beta of growth opportunities and beta of asset. This will help maintaining project beta. To do so, we perform the model of Bernardo, Chowdhry and Goyal (Bernardo,

Chowdhry, & Goyal, Growth Options, Beta, and the Cost of Capital, 2007) (hence forward we call it BCG). The idea is that the value of a company can be separated between value of growth opportunities and value of assets that are already in place. If so, the unlevered beta would be a weighted average of the 2 mentioned betas. We made 2 assumptions in this paper. First: ratio of value of existing assets to the value of firm is proxied by book to market ratio; and second: beta of existing asset and growth opportunities are constant for all firms in an industry.

The contribution of this research is to adjust the BCG model to break down beta into beta of assets and beta of growth opportunities for all industries more accurately. To make the model more precise, a limit was added for the least amount of the firms that an industry could have. Aside from the mentioned point, the research shows the inconsistency and inefficiency of CAPM beta to explain systematic risk of industries.

The paper goes on as follows: after reviewing other researches, we demonstrate the relation between betas and growth opportunities. Next, we present the calculated results. Then we provide some robustness tests and finally we offer our conclusion.

Literature Review

CAPM model is still the most common model for company valuation and project evaluation. This model has been investigated and examined multiple times over the past years. For example Mohamadi, and others (Moamadi, Abasinejad, & Mirsanei, 2007) examined different periods and methods of estimating beta (I.E. Ordinary Least Squares, Maximum Likelihood, Least Absolute Errors, Non Parametric Regression, …) and showed that there is a rather big difference between different methods but monthly return and nonparametric regression helps managers better than other methods.

Also, in 2007, Rahnamay Roodposhti, and his team compared the power of the beta of CAPM and the variables of Fama-French Model in explaining stocks earnings. They realized that while the size of the firm, A/V, DPS/Price have great power in explaining the companies' earnings, without beta the power of other factors would be gone (RahnamayRoodposhti, Nikoomaram, & Alimardani, Reviewing and comparing the power of beta in capital asset pricing model and the variables presented in the Fama and French model for explaining stock returns, 2007). In another case, Rahnamay Roodposhti and houshmand Neghabi did a comparative study between CAPM models and X-CAPM models in Tehran between the years 2006-2015 and concluded that X-

CAPM does not possess enough capability relative to CAPM models (RahnamayRoodposhti & Houshmand Neghabi, Comparative Study of Capital Assets Pricing Models (CAPM) with Extrapolating Capital Assets Pricing Models (X-CAPM) in Tehran Exchange Market, 2016).

However, as mentioned in the previous section, beta in the CAPM model does not consider growth opportunities of projects or firms. It is known that firms with bigger growth options must have bigger beta (Bernardo, Chowdhry, & Goyal, Growth Options, Beta, and the Cost of Capital, 2007). The reason is that greater growth opportunities leads to more various options for companies and these extra options acts as a leverage and could affect cash flows. The systematic risk of growth options must be higher than the systematic risk of existing assets (Berk, Green, & Naik, Valuation and Return Dynamics of New Ventures, 2004; Carlson, Fisher, & Giammarino, 2006).

In some researches (I.E. (McDonald & Siegel, 1985), (Berk, Green, & Naik, Optimal Investment, Growth Options and Security Re-turns, 1999)) there was strong evidence that firm's value includes both existing projects and future options for new projects and modifications of existing projects.

Bernardo, Chowdhry and Goyal mentioned that the firm's capital return has risks for the reason of existing projects and growth opportunities and showed that calculating discount rate with the usual method for CAPM model can overstate project capital rates by up to 2-3 percent (Bernardo, Chowdhry, & Goyal, Assessing Project Risk, 2012).

After publication of the mentioned article, gradually their work attracted more and more attention. In another research, Bukhvolov reasoned that since value of the firm should be more related to management actions than the average of the industry. He used BCG model to analyze cash flows of Italian companies and measure their systematic risk (Bukhvalov, 2016).

Da, Guo and Jagannathan devised a method for estimating firm's existing-projects' beta and project returns. They realized that there is a linear relationship between these two and that the usage of CAPM should still be supported along with real option valuation models (Da, Guo, & Jagannathan, 2012). Jia and Yan investigated the profitability skewness on expected stock return. They realized that profitability skewness positively predicts cross-sectional stock return they confirmed profitability skewness is positively related to firm growth opportunity and future profitability (Jia & Yan, 2017). Also, Jafarizadeh and Bratvold combined BCG method and Da, Gou and Jagannathan model with decision analysis principles and devised a method to valuate petroleum companies in the U.S. market (Jafarizadeh & Bratvold, 2019).

Askarinejad Amir and Fadaeinejad studied jump beta and continuous beta as indicators of systematic risk, and their determinants in banking, investment and insurance industry. They concluded that the value of jump beta was higher than continuous beta (Askarinejad & Fadaeinejad, 2018).

Using other methods in valuation of firms and their options and also risk evaluation has been tested in other researches. As an example, we can refer to Mohammadi and Asima's research on pricing unsystematic risk using five factored Fama-French model (Mohammadi & Asima, 2019) or Abvali and other's paper on pricing options using a new analysis of the Black-Scholes formula (Abvali, Khalili araghi, hasanabadi, & yaghoobnezhad, 2019). Another interesting example would be Mirzaei, Sahebgharani and Hashemi's work which examined 168 listed companies of Tehran Stock Exchange to measure the prediction strength of Fama-French model which was introduced in 2015. They came to the conclusion that profitability and investment factors couldn't explain excess return and that the model's strength is not verified (Mirzaei, Sahebgharani, & Hashemi, 2017).

Relation between Beta and Growth Opportunities

As it has been discussed in the literature, there exists a link between beta of a company and its growth opportunities. Researches like Carlson, Fisher and Giammarino (Carlson, Fisher, & giammarino, 2004), (Carlson, Fisher, & Giammarino, 2006) confirm this relation. In fact, what BCG did is a simplified and modified version of the work of Carlson, Fisher and Giammarino.

Consider a company with existing assets A_t at time t. The diffusion process is as follows:

$$dA_t/A_t = \mu dt + \sigma dz_t \quad (1)$$

μ: expected growth rate of the return on existing assets,

σ: return volatility,

z_t: A standard wiener process.

Also, imagine that the firm has a growth opportunity which can increase the cash flow for an investment of I. If G_t is the firm's growth opportunity and the investment's return prevails at time t+T, the value of G_t is calculable by the

following formula:

$$G_{i,t}=N(d_1)A_t - N(d_2)Ie^{-rT} \quad (2)$$

$$d_1=\frac{ln\left({A_t}/{Ie^{-rT}}\right)+(r+\frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \quad (3)$$

$$d_2=d_1 - \sigma\sqrt{T} \quad (4)$$

$N(.)$: Cumulative distribution functions for the standard normal distribution.

If β_t^A is the beta of firms existing assets and β_t^G is the beta of firms' growth opportunity, it is safe to say:

$$\beta_t^G=\frac{{dG_t}/{dA_t}}{{G_t}/{A_t}}\beta_t^A \quad (5)$$

And we know that$\frac{dG_t}{dA_t} = N(d_1)$. So we can say$\beta_t^G > \beta_t^A$. This means a firm's growth opportunity is like an option on existing assets and because it has implicit leverage, β_t^G is greater thanβ_t^A.

There are other researches that link betas and growth opportunities ((Berk, Green, & Naik, Valuation and Return Dynamics of New Ventures, 2004), (Campbell & Mei, 1993), (Cornell, 1999), (Dechow, Sloan, & Soliman, 2004)). Betas are in link with variation in expected returns and as the cash flows from growth opportunities are realized in the future, the impact of variation in expected returns has to be greater in firms with growth opportunities.

Let's imagine company i with growth opportunities $G_{i,t}$ and existing assets$A_{i,t}$. The value of the company is divided as follows:

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

So the firm's beta is a weighted average of the beta of existing assets and beta of growth opportunities:

$$\beta_{i,t} = \frac{A_{i,t}}{V_{i,t}}\beta_{i,t}^{A} + (1 - \frac{A_{i,t}}{V_{i,t}})\beta_{i,t}^{G} \quad (7)$$

According to BCG, to make this work we have to make 2 assumptions: First, the ratio of the value of existing assets to the total value of the firm $\frac{A_{i,t}}{V_{i,t}}$ can be proxied by$\frac{D+E_B}{D+E_M}$. D is the book value of long term outstanding debt, E_B is the book value of Equity and E_M is the Market Value of Equity. Second, we assume that the beta of existing assets and beta of growth opportunities are the same for all firms in the same industry. With these 2 assumptions, we have:

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

$\beta_{i,t}$ is the unlevered beta ,which is calculated using the conventional beta formula (one factor market model) and then is unlevered using the following formula:

$$\beta_{i,t} = \frac{\beta_{i,t}^E}{1 + (1-t)(D/E)} \quad (9)$$

Then we estimate the intercept and slope (β_t^G , β_t^A) of the cross-sectional regression:

$$\beta_{i,t} = \beta_t^G - (\beta_t^G - \beta_t^A)\frac{A_{i,t}}{V_{i,t}} + \varepsilon_{i,t} \quad (10)$$

$\varepsilon_{i,t}$ is the measurement error.

Research Methodology

This research is applied in terms of purpose and correlational and post-event in terms of research method.

Population and sample

The population of this research is all listed companies in Tehran Stock Exchange and Iran Fara Bourse between the 2nd February 2010 and 19th February 2019 that have the following criteria:

1. Have been dealt actively in the stock market from at least 2018,

2. The firms deals have not been taking place in IFB third market (any other market including main board and secondary board of First market and second market of TSE and IFB's first and second market are fine),

3. More than 5 companies exist in the industry,

4. The firms are not part of investment or banking industry .

Since our analysis covers the data of 1 to 10 years between the years 2010-2019 for all available firms with the mentioned properties, it is safe to say that this research covers the whole population and that is the reason this paper does not need a sample selection method.

It is worth mentioning that the data of industries that have reached our 6 company limit in recent years were added to our research. After filtering our data for the above limits we are left with 289 companies which are listed in 19 different industries (table 1). The categories of firms into industries are compatible with TSE categories of industries. The time periods start from 20nd February to 19th February (first of day of Esfand and 30th of Bahman in Persian Calendar) of the next and the betas are calculated from 1 to 10 years for each industry.

Table 1 . Number of Companies in each industry

Number of companies	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Chemicals & Chemicals – products	30	30	29	27	26	25	21	21	15	15
Pharmaceuticals & Medicinal Products	32	32	31	29	27	26	24	24	23	22
Cement, Lime & Plaster	28	28	28	28	27	26	26	26	24	20
Food Products and Beverages except sugar	27	27	26	22	21	19	19	19	18	17
Basic Metals	25	25	24	24	22	21	21	19	14	15
Motor Vehicles And Auto Parts	24	24	24	24	23	23	23	23	20	18
Real Estate And Construction	17	17	17	17	16	15	14	12	8	8
Sugar & By-products	13	13	13	13	12	12	12	11	10	8

Other Non-metallic Mineral Products	12	12	12	12	11	11	11	11	10	11
Refined Petroleum Products	11	11	11	11	11	10	8	5	5	4
Transportation and Storage	10	10	9	6	6	5	4	3	3	2
Computer & Related Activities	10	10	9	8	8	8	7	5	3	2
Machinery & Equipment	10	10	10	10	10	10	10	10	10	9
Electrical Machinery & Apparatus	8	8	8	8	8	8	8	8	8	7
Metal Ores Mining	7	7	7	7	7	7	7	6	5	3
Rubber & Plastic Products	7	7	7	7	7	6	6	6	6	2
Power, gas, steam and hot water supply	6	6	5	3	1	0	0	0	0	0
Ceramic & Tiles	6	6	6	6	6	6	6	6	3	3
Fabricated Metal Products except Machinery & Equipments	6	6	5	5	5	5	5	5	5	5

Model

To do this research, the monthly return of all listed firms and TEDPIX indices between the 2nd of February 2010 and 19th of February 2019 were gathered. Then the firms that did not meet the mentioned properties in the previous section of the paper, were omitted. The remaining 289 firms were divided into 19 industries (as shown in table 1). Then, based on their last Audited Financial statements, we fetched the book value of Debts and Equities of each firm. Also, using Rahavard Novin software, the market value of each company was gathered.

Using the mentioned industry classification, we calculate the CAPM beta for each firm. The next step is the calculation of beta of each industry using a weighted average of beta of firms in each industry according to their market value. It is known that the calculated beta is levered and in order to unlever the industry beta, we use the debt to equity ratio and formula 9. For the purpose of

abbreviation, we do not provide the mentioned results.

To calculate the asset beta and growth beta, we use formula 10. As mentioned before, the ratio of the value of existing assets to the total value of the firm $\frac{A_{i,t}}{V_{i,t}}$ can be proxied by $\frac{D+E_B}{D+E_M}$. So we calculate the ratio $\frac{D+E_B}{D+E_M}$ for each firm and then calculate the weighted average of said ratio for each industry according to market value of each firm. Then using the regression model of formula 10, we estimate β_t^A and β_t^G for each industry and for the period of 1 to 10 years. To test the accuracy of our regressor in each industry, we use a bunch of robustness tests.

Results

The table below provides 1 to 10 years of asset and growth betas and the difference between them for all industries that contains more than 5 companies. In 7 out of 14 industries growth beta is bigger than asset betas (Electrical Machinery & Apparatus, Transportation and Storage, Refined Petroleum Products, Other Non-metallic Mineral Products, Sugar & By-products, Basic Metals, Food Products and Beverages except sugar). An interesting case is pharmacy industry in which the difference is positive in 1-5 years beta and negative in 6-10 years betas. In 6 industries (Computer & Related Activities, Machinery & Equipment, Real Estate And Construction, Motor Vehicles And Auto Parts, Cement, Lime & Plaster, Chemicals & Chemicals –products) the difference is absolutely negative in 1 – 10 years beta.

Table 2. Beta of Assets, Beta of Growth Opportunities and the difference between the 2 betas for all industries

Years	1 year			2 years			3 years			4 years			5 years		
Industries	Ba	Bg	diff	Ba	Bg	diff	Ba	Bg	diff	Ba	Bg	diff	Ba	Bg	diff
Chemicals & Chemicals – products	0.12	0.27	-43%	0.11	0.32	-38%	0.09	0.32	-44%	0.26	0.29	-40%	0.25	0.29	-38%
Pharmaceuticals & Medicinal Products	0.37	0.31	18%	0.39	0.33	23%	0.4	0.31	-1%	0.49	0.25	8%	0.52	0.17	7%
Cement, Lime & Plaster	0.7	0.92	-7%	0.71	0.94	-5%	0.88	0.77	-10%	0.78	0.85	-24%	0.78	0.87	-35%

Food Products and Beverages except sugar	0.21	0.07	15%	0.25	0.08	21%	0.31	0.1	23%	0.71	0.32	3%	0.75	0.32	4%
Basic Metals	0.33	-0.02	22%	0.35	-0.03	23%	0.35	-0.05	-11%	0.46	0.3	7%	0.47	0.45	9%
Motor Vehicles And Auto Parts	-5.04	2.22	-14%	-4.41	1.96	-18%	-2.96	1.42	-21%	-2.91	1.35	-39%	-0.72	0.66	-44%
Real Estate And Construction	0.54	0.29	-35%	0.54	0.37	-38%	0.42	0.42	-40%	0.42	0.57	-16%	0.29	0.74	-2%
Sugar & By-products	0.32	1.62	726%	0.23	1.7	637%	0	1.82	438%	-0.88	2.3	426%	-0.86	2.25	139%
Other Non-metallic Mineral Products	0.67	0.15	-25%	0.69	0.17	-18%	0.74	0.09	0%	0.74	0.21	15%	0.72	0.27	45%
Refined Petroleum Products	0.28	0.26	130%	0.28	0.22	147%	0.32	0.14	182%	0.74	0.28	318%	0.84	0.29	311%
Transportation and Storage	1.03	-0.32	114%	0.95	-0.19	126%	1.06	-0.32	130%	1.37	-0.34	-	1.3	-0.25	-
Computer & Related Activities	-0.1	0.63	-2%	-0.2	0.71	-6%	-0.29	0.76	-18%	-0.18	0.71	-47%	-0.22	0.75	-56%
Machinery & Equipment	-0.21	0.93	-53%	-0.24	1.03	-51%	-0.28	1.02	-66%	-0.29	1.3	-53%	-0.16	1.3	-45%
Electrical Machinery & Apparatus	1.99	0.73	72%	2.53	0.6	91%	2.82	0.45	105%	3.14	0.31	89%	3.33	0.24	97%
Metal	0.	0.	-	1.	-	-	1.	-	-	1.	-	-	1.	-	-

Ores Mining	69	16		19	0.16		41	0.26		15	0.1		11	0.03	
Rubber & Plastic Products	0.57	0.09	-	0.59	0.1	-	0.5	0.1	-	0.89	0.08	-	0.81	0.13	-
Power, gas, steam and hot water supply	1	0.12	-	1.43	0.03	-	1.64	0.05	-	1.49	0.22	-	1.2	0.38	-
Ceramic & Tiles	0.05	0.43	-	0.23	0.38	-	0.93	0.15	-	-	-	-	-	-	-
Fabricated Metal Products except Machinery & Equipments	0.76	0.67	-	0.76	0.72	-	0.76	0.77	-	1.29	0.7	-	-	-	-

Table 2 . continued - Beta of Assets, Beta of Growth Opportunities and the difference between the 2 betas for all industries

Years	6 years			7 years			8 years			9 years			10 years		
Industries	Ba	Bg	diff	Ba	Bg	diff	Ba	Bg	diff	Ba	Bg	diff	Ba	Bg	diff
Chemicals & Chemicals – products	0.56	0.5	-36%	0.66	0.76	-39%	0.67	0.73	-36%	0.62	0.75	-27%	0.73	0.63	-21%
Pharmaceuticals & Medicinal Products	0.71	0.32	-1%	0.66	0.3	-18%	0.65	0.28	-19%	0.62	0.27	-15%	0.64	0.36	-14%
Cement, Lime & Plaster	0.55	1	-39%	0.57	1.01	-36%	0.75	0.77	-37%	0.52	0.91	-34%	0.74	0.79	-28%
Food Products and Beverages except sugar	0.79	0.3	-6%	0.74	0.22	10%	0.77	0.23	6%	0.82	0.29	13%	0.85	-0.01	-10%
Basic Metals	0.57	0.71	46%	0.53	0.65	45%	0.52	0.19	2%	0.49	0.1	39%	0.49	0.11	5%
Motor	-	0.	-	-	0.	-	-1	0.	-	-	0.	-	-	0.	-

Vehicles And Auto Parts	0.53	62	49%	0.22	48	51%		6	54%	0.85	63	53%	0.53	55	86%
Real Estate And Construction	0.41	1.01	14%	0.4	0.89	13%	0.39	0.84	-33%	0.36	0.77	-39%	0.32	0.77	-38%
Sugar & By-products	-0.43	1.99	115%	-0.81	2.02	70%	0.71	1.24	160%	0.22	1.37	149%	5.65	-1.21	108%
Other Non-metallic Mineral Products	0.88	0.53	60%	0.82	0.53	50%	0.81	0.5	46%	0.73	0.49	41%	0.67	0.49	45%
Refined Petroleum Products	0.81	0.3	241%	1.03	0.18	283%	0.94	0.31	-	1.33	0.28	-	2.16	0.21	-
Transportation and Storage	1.06	0.3	-	1.05	0.32	-	0.92	0.37	-	1.17	0.27	-	1.35	-0.15	-
Computer & Related Activities	-0.35	1.14	-51%	-0.31	1.02	-	-0.29	1	-	-0.37	1.09	-	-0.35	1.04	-
Machinery & Equipment	0.29	1.01	-35%	-1.71	3.14	-29%	-1.02	2.21	-30%	-1.7	2.97	-24%	-0.33	1.66	-17%
Electrical Machinery & Apparatus	3.44	0.15	148%	3.57	0.15	133%	4.98	-0.31	130%	5.16	-0.4	146%	5.67	-0.69	-
Metal Ores Mining	1.61	0.05	-	1.41	0.12	-	1.18	0.17	-	1.61	0.04	-	1.17	0.17	-
Rubber & Plastic Products	0.81	0.45	-	0.82	0.35	-	0.86	0.33	-	0.88	0.35	-	0.97	0.32	-
Power, gas, steam and hot water supply	1.08	0.59	-	1.3	0.47	-	1.61	0.42	-	1	0.46	-	-	-	-

Ceramic & Tiles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fabricated Metal Products except Machinery & Equipments	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

To test the significance of the differences between assets beta and growth beta in all industries, we performed a 2 sample mean test. The null hypothesis here is that the mean difference is 0. The result of this test is shown in table 3. As it is clear, due to high P value, it is not possible to reject the null hypothesis.

Table 3. z Test: Two Sample for Means

	Ba	Bg
Mean	0.498582	0.533036
Known Variance	1.15498	0.25317
z	-0.36497	
P(Z<=z) one-tail	0.357568	
z Critical one-tail	1.644854	
P(Z<=z) two-tail	0.715136	
z Critical two-tail	1.959964	

Just like BCG, our results show the importance of investment beta and the proportion of growth opportunities to assets in place. That is, beta of assets in place is more suitable for firms with no or fewer opportunities to grow and beta of growth opportunities is more suited for young startups and unfinished projects. Of Corse, when it comes to practice, it is better to reduce the data noise (I.E. noise in the B/V ratio) to have better results.

Robustness Tests

As mentioned before, the ratio of book to market is a noisy proxy for the ratio $\frac{A_{i,t}}{V_{i,t}}$. We could use other proxies to determine the value of assets in place. One way would be to calculate the ratio of cash flows to firm's discount rate ($A_{i,t} = \frac{C_{i,t}}{r_i}$). Unfortunately 63% of the companies (249 out of 398) did not have cash flows bigger than 0. So it cannot be a good proxy. We could also use earnings in the numerator but almost 28% (111 out of 398) of the companies

had no positive profit.

We have to accept the possibility that the value of existing assets may exceed the total value of the company which makes the value of growth opportunities negative. It will be probable, for example, if the firms cash flows are expected to fall over the next years. It might also be the noise in our estimators.

To see if the noise in our proxy has bias downward the slope coefficients in our regressions, we performed two robustness tests.

We repeated our calculations by constructing two, four and eight portfolios and compare the results to see if slope coefficients are smaller when regressor is more disaggregated. But due to small amounts of companies in each industry in Tehran Stock Exchange, it is not possible to make have diversified enough portfolios in most of the industries.

As a test, instrumental variables regression, which is a standard approach to deal with measurement error, has been used. The problem here is finding variables with uncorrelated measurement error with our proxy (book to market). We choose three instruments for this purpose: Earnings to price ratio (E/P), the cash flow to price ratio (CF/P) and dividend yield (D/P). BCG chose the same variables and performed the Hausman specification test for each of these regressions. Here we perform both Hausman and Durbin test.

Table 4 shows the summary of Durbin and Hausman test for all the industries. The null hypothesis is: The regression error is uncorrelated with the regressor. The Hausman test does not reject the null hypothesis (at 10% significance level) in almost 22% of the cases (12.5% for CF/P, 44.6% for D/P, 10.4% for E/P) and at the same level of significance, the Durbin test also does not reject the null in approximately 31% of the companies (15.9% for CF/P, 44.6% for D/P, 31.5% for E/P). In the cases where the null is not rejected in both tests, we use the IV estimate but in the rest of the cases, we use the OLS estimate for the slope coefficient.

Table 4. Robustness Tests Summary Results

Robustness test comparison at 10% significance level	E/P		D/P		CF/P		average	
	Durbin	Wu-Hausman	Durbin	Wu-Hausman	Durbin	Wu-Hausman	Durbin	Wu-Hausman
IV Regress	31.5%	10.4%	44.6%	44.6%	15.9%	12.5%	31%	22%

The comparison between the three used variables shows that D/P ratio is the best instrument for explaining changes in the explanatory variable. But neither of these variables could provide solid enough results. Table 5 shows the results of Durbin and Hausman test by industry.

Table 5. Robustness Tests Detailed Results

Industries	CF to P				D to P				E to P			
	Durbin		Wu-Hausman		Durbin		Wu-Hausman		Durbin		Wu-Hausman	
	Score	p	F	P	Score	p	F	P	Score	p	F	P
Chemicals & Chemicals – products	0.626342	0.4287	0.575728	0.4546	12.9565	0.0003	20.5255	0.0001	7.19833	0.0073	8.5845	0.007
Pharmaceuticals & Medicinal Products	1.6872	0.194	1.61413	0.214	1.09238	0.2959	1.02496	0.3197	2.46807	0.1162	2.42205	0.1309
Cement, Lime & Plaster	0.282119	0.5953	0.254456	0.6184	5.6772	0.0172	6.35807	0.0184	2.80125	0.0942	2.77915	0.108
Food Products and Beverages except sugar	0.096237	0.7564	0.085449	0.7727	0.43411	0.51	0.390541	0.5382	0.326369	0.5678	0.292382	0.5939
Basic Metals	2.99828	0.0834	2.99803	0.098	4.18124	0.0409	4.43045	0.0475	2.9183	0.0876	2.90699	0.1029
Motor Vehicles And Auto Parts	1.97999	0.1594	1.88827	0.1839	0.03847	0.8445	0.033716	0.8561	0.032332	0.8573	0.028328	0.8679
Real Estate And	0.011316	0.9153	0.009325	0.9244	0.537876	0.4633	0.457429	0.5098	0.014643	0.9037	0.012069	0.9141

Construction														
Sugar & By-products	2.45114	0.1174	2.32 36	0.1584		4.47965	0.0343	5.25758	0.0448		0.14863 3	0.6998	0.11565 5	0.7408
Other Non-metallic Mineral Products	0.64130 4	0.4232	0.50813 4	0.494		4.62278	0.0316	5.63966	0.0416		0.22774	0.6332	0.17410 9	0.6863
Refined Petroleum Products	4.75672	0.0292	6.09516	0.0388		5.36733	0.0205	7.62315	0.0246		1.669	0.1964	1.43093	0.2659
Transportation and Storage	2.90074	0.0885	2.85354	0.1421		0.20320 3	0.6521	0.13859 8	0.7225		0.21223 4	0.645	0.14490 6	0.7166
Computer & Related Activities	0.96031 7	0.3271	0.71668 3	0.4297		3.91245	0.0479	4.61415	0.0753		0.91767	0.3381	0.68124 1	0.4407
Machinery & Equipment	0.02784 6	0.8675	0.01954 7	0.8927		1.1834	0.2767	0.93956 7	0.3647		2.22174	0.1361	1.99944	0.2003
Electrical Machinery & Apparatus	1.2262	0.2681	0.90510 7	0.3851		1.3501	0.2453	1.01513	0.3599		3.50816	0.0611	3.90505	0.1051
Metal Ores Mining	1.28859	0.2563	0.90246 6	0.3959		1.69873	0.1925	1.28175	0.3208		1.57888	0.2089	1.16499	0.3412
Rubber & Plastic Products	0.16266 6	0.6867	0.09516 3	0.7731		0.32906 5	0.5662	0.19731 2	0.6799		0.64080 1	0.4234	0.40307	0.56
Power, gas, steam	0.71422 4	0.398	0.40536 5	0.5696		0.96429 3	0.3261	0.57447 3	0.5036		0.89025 3	0.3454	0.52267 9	0.522

and hot water supply														
Ceramic & Tiles	0.30920 2	0.5782	0.16300 1	0.7135		0.22922 9	0.6321	0.11916 7	0.7527		0.00065 4	0.9796	0.00032 7	0.9867
Fabricated Metal Products except Machinery & Equipments	1.29677	0.2548	0.82716 1	0.4301		2.13456	0.144	1.65665	0.2884		3.96727	0.0464	5.85509	0.0942

Also, it is worth mentioning that the difference between asset and growth betas for all industries (with at least 6 companies) in all years, is on average 3.4% which is close to the result 3.1% when using D/P as instrument.

Conclusion

In this paper we calculated beta of assets and beta of growth opportunities for 19 industries using an adjusted method of BCG. The calculated betas for each industry have time periods of 1 to 10 years. The explained method has the ability to measure the risks of options and correct for the effects of financial leverage. Using this method causes different betas which would lead to different discount rates and as a result, different economic decisions. The average of differences between asset and growth betas for all industries during the studied time period was 3.4%. This means a company with great growth options should have (on average) a 3.4% higher beta compared with a company without those growth opportunities.

Also, according to table 4, the results of the robustness tests show that none of our instrumental variables are strong enough to explain book to market ratio.

Comparison with previous researches

Many researches have been aimed at investigating the beta of industries, both inside and outside of Iran. But as mentioned in the Literature review, not all of them addressed the effects of growth options on beta. A useful comparison is between this research and Jafarizadeh and Bratvold's work (Jafarizadeh & Bratvold, 2019). They combined BCG model and Da, Gou and Jagannathan's

method and evaluate petroleum companies in US stock market. Here we presented 1 to 10 years of growth and assets betas for all available industries and firms that meat necessary criteria.

Also, our results confirm BCG: When using CAPM to investment projects with numerous options to expand, there should be a higher cost of capital than projects in mature competitive markets. When choosing comparables to estimate beta of the project, we should choose similar companies with similar growth opportunities.

It is true that noise exists in the estimated betas for each company and that's why many suggest applying industry beta for all firms in the industry (Fama & French, 1997). BCG suggests that there should be three betas calculated in each industry: the average unlevered beta for all firms with low market-to-book ratios, the average unlevered beta for all firms with high market-to-book ratios, the average unlevered beta for all firms within the industry. But in our research, due to the result of robustness tests and unmeasurable noise in our data, the suggestion does not stand correct. We suggest the use of formula (10) and table (2). This way we can adjust the project beta for its growth options.

Another aspect of BCG was that in almost all industries growth betas are bigger than asset bettas. But our findings shows that growth beta is bigger than asset beta in only 7 out of 19 industries (Electrical Machinery & Apparatus, Transportation and Storage, Refined Petroleum Products, Non-metallic Mineral Products, Sugar & By-products, Basic Metals, Food Products and Beverages except sugar). BCG finings is not confirmed in this regard.

Discussion and Recommendation

One aspect of the noise in our proxy ($\frac{A_{i,t}}{V_{i,t}}$) is because of the rather big difference between real value of the existing asset and its book value. Due to sudden increase in foreign currencies, prolonging inflation and Tax issues surrounding revaluation process, many of the companies have a great difference between the book value and market value of existing assets. Recently there has been some efforts to legalize tax exemption for the process of capital increase from the source of revaluation of assets. But right now we were not able to reduce this noise from our data.

A good application of our study is the estimation of discount rate for projects. As discussed before, the beta of projects and firms with growth options must be considered higher than the average beta of the industry and as

a result, the rate to discount future cash flows must be higher. The method discussed in this paper prevents overvaluation of projects and firms by providing a more accurate beta and discount rate. Another application of our study is the estimation of beta and discount rate for startups. If we consider a startup as a firm with no or small amount of assets and only growth options, we can determine the beta and discount rate with our method and CAPM model.

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