Conservatism in Corporate Valuation

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Abstract

Using a CCAPM based risk adjustment model, consistent with general asset pricing theory, I perform corporate valuations of a large sample of stocks listed on NYSE, AMEX and NASDAQ. The model is different from the standard CAPM model in the sense that it discounts forecasted residual income for risk in the numerator rather than trough the cost of equity, in the denominator. Further, the risk adjustment is based on assumptions about the time series properties of residual income return and consumption rather than historical returns. I compare the pricing performance of the model with the standard CAPM based valuation model, both considering the absolute valuation errors and an investment setting where simple investment strategies are made based on the results of the respective models. The CCAPM model performs substantially better than the CAPM based model when comparing absolute valuation errors. Both models are able to explain abnormal returns impressively well, when constructing investment strategies, but also in this setting the CCAPM model outperforms the CAPM model in most dimensions.

I further show that the standard CAPM and the Fama-French 3 factor based approaches to risk adjustment substantially overestimate the cost of risk. This "error" more than offsets yet another "error", committed when using analyst's forecasts of long-term growth which are 3-4 times higher than what can be considered reasonable. Using the CCAPM approach to valuation, the results imply that investors are very conservative in their valuation of long-term value generation and very conservative in risk adjusting future value generation.

JEL Classifications: C22, C32, C51, C53, G11, G12, G14, G32.

Keywords: Accounting beta, corporate valuation, Compustat, cost of capital, covariance risk, CRSP, I/B/E/S, residual income, risk adjusted discounting, CAPM, CCAPM

1 Introduction

The theory of corporate equity valuation (in short, corporate valuation) is a cornerstone in the accounting and finance literature. In this paper I perform corporate valuations of a large sample of companies listed on NYSE, AMEX and NASDAQ using a CCAPM for risk adjustment. The model draws on a general asset pricing equation proposed by Rubinstein (1976) to separate discounting for risk and time. Assuming return on equity follows a first order autoregressive process, and that aggregate consumption grows at a constant rate, I derive a closed form solution for the risk adjustment. I compare the performance of the CCAPM model with the performance of a large variety of the standard CAPM and Fama-French three factor based valuation models in two different settings. First, model implied values are compared with market values. The best standard model produces between 27 and 59 percent higher median absolute pricing errors compared to the CCAPM model, depending on sample and CCAPM model assumptions. Secondly, a simple investment strategy is performed. Here stocks are placed in portfolios based on whether the models suggest that the stocks are cheap or expensive. The performance of the portfolios is measured by subsequent raw returns, risk adjusted (CAPM and Fama-French three factors) returns, Sharpe ratios and Sortino ratios. For no measure the CCAPM model is performing worse than the CAPM model at identifying cheap and expensive stocks and in many settings it performs substantially better.

The results in this paper suggest that while analyst's forecasts of long term growth rates are upwards biased they still contain important information about fundamental company value. This is seen when long term growth rates are used in the CCAPM model. In this they greatly improve the ability of the model to forecast subsequent Fama-French risk adjusted return. In the standard CAPM model the relevant information in forecasts of long term growth rates is contaminated by the noise in the risk adjustment, and this model is in no setting able to predict subsequent Fama-French risk adjusted returns. The CCAPM valuation model in this paper suggests that investors are very conservative both in their valuation of long term growth and risk adjustment of future residual income.

In practice, corporate valuation is, in general, perceived as a three step procedure. The first and second steps consist of a strategic and an accounting analysis of the company. In third step, based on the information obtained from the first two steps, analysts forecast earnings and discount these to obtain their value, adjusted for risk and time. This paper focuses on the third step which can again be seen as consisting of three elements. First, forecast earnings. Second,

choose accounting structure. Third, discount for time and risk.

Forecasting earnings is probably the hardest part of any valuation. I follow the literature by using analyst's consensus forecasts from the I/B/E/S database. While this is an easy way to get around the daunting task of forecasting earnings, any researcher must remain critical in any use of such forecasts and especially of the forecasts of long-term growth rates. In any valuation course students are told that the terminal growth rate must not exceed the growth of the general economy. If this happens the company is assumed to overtake the world. I/B/E/S data reveals analysts forecasts of earnings up to 5 years ahead, and while 1 and 2 year ahead forecasts are in general quite accurate, the 3-5 year forecasts are substantially upwards biased, as also noted by Frankel and Lee (1998) and Hermann et al. (2008). In fact, these forecasts imply annual growth rates of 13-15 percent on average trough the period 1982-2008, roughly 3-4 times larger than what is usually considered an upper limit of the nominal growth rate of the economy (4-5 percent). I show that the forecasts of long-term growth rates of earnings are necessary for the standard CAPM and the Fama-French three-factor models, since without it these models would substantially undervalue companies. The CCAPM valuation model suggests that investors are much more conservative in their forecasts of long-term growth compared to those given by the analysts.

As has become common in the accounting literature, I cast all valuation models in the residual income valuation framework which provides a simple and intuitive link between the value of corporate equity and the accounting numbers.[1,2] Many practitioners tend to favor the dividend discount model or the free cash flow model. However, given the so-called clean surplus relation, this choice of accounting structure in the valuation has no effect on the valuation result. Several advantages of the residual income model have been stated in the literature. According to Penman and Sougiannis (1998) and Francis et al. (2000), utilizing the accrual accounting in the residual income model, the errors committed in truncating the model (to have a finite forecast horizon) are reduced compared to the free cash flow and dividend discount models. Probably the best motivation to use the residual income model is given by Penman (2009), who argues that residual income is a good measure of value creation, and it utilizes what analysts forecast, i.e. earnings.

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[1]In the residual income valuation model the value of corporate common equity is the current book value of equity plus the present value of future residual income (see e.g. Feltham and Ohlson (1995) and Ohlson (1995)).

[2]The RI model is well established in the literature both within financial statement analysis for corporate valuation (see e.g. Ohlson (1995), Brief and Lawson (1992), and Lee et al. (1999)), principal-agent incentive contracting (see e.g. Reichelstein (1997), Rogerson (1997), Dutta and Reichelstein (1999), and Baldenius and Reichelstein (2005)), and optimal capital structure decissions (see Stoughton and Zechner (2007)).

Since the development of the capital asset pricing model (CAPM) by Sharpe (1964), Lintner (1965), and Mossin (1966), the theory of risk adjustment has received much attention, and significant theoretical progress has been made. However, CAPM is still by far the single most frequently applied method for risk adjustment by practitioners. This is no surprise since only few advances have been made in developing practically applicable risk adjustment models, and even less empirical evidence has been presented on the performance of these models. In corporate valuation there are two general approaches to discounting for time and risk. The first, and most common, approach is to calculate a discount factor which is both adjusting for risk and timing of future residual income, by the sum of a risk-free rate and a risk premium. Usually the risk-free rate is the 10 year Treasury yield, and the risk premium is determined from past returns, using a factor model, e.g., the CAPM or Fama-French model (the standard models). The second approach follows Rubinstein (1976). This first discounts future residual income for risk and nexts use a risk-free rate to discount for time. This method of discounting for risk is broadly referred to as numerator-based discounting since discounting for risk is done in the numerator, rather than in the denominator as in the standard models. Disentangling discounting for risk from discounting for time allows the analyst to investigate the relative relevance, and I show that investors are much more conservative in their adjustment for risk than what is implied by the standard models.

Analysts forecast earnings, and it is appealing to believe that these earnings are generated from fundamentals of the company, and that these fundamentals are reflected in the accounting numbers. If this is the case, a natural approach to risk measurement is to apply accounting data for the purpose of risk adjustment instead of (or maybe together with) past returns which is the standard approach. Risk measurement using accounting data has received much theoretical attention in recent years (see, e.g., Barth et al. (2001), Begley and Feltham (2002), Christensen and Feltham (2009), Nekrasov and Shroff (2009) and Penman (2010)). Despite the theoretical attention and the practical relevance, only little empirical work has been done to apply the theory for empirical studies in corporate valuation.[3] The valuation model proposed by Christensen and Feltham (2009) (CF) (the CCAPM model) also falls within this literature, and calculates risk adjustment from the time series properties of accounting data. It further follows Rubinstein (1976) and disentangles discounting for risk from discounting for timing of future residual income.

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[3]Nekrasov and Shroff (2009) conduct the only large scale empirical study I know of.

I compare the CCAPM model with the standard model. The standard model is implemented using the CAPM and Fama-French three factors as well as various assumptions about risk-premia and the terminal growth rate. The CCAPM model is somewhat more complex to implement compared to the standard models. However, it is consistent with classical asset pricing theory and does not rely on historical return data and can therefore be used for valuation of IPOs or major investments.

The standard models in general produce values that are too low compared to market values. This is somewhat surprising considering the fact that analysts are too optimistic about future long-term growth. The only possible explanation for this is that another but very different error is committed in the valuation process. Since the models only have two sources of difficulties, namely forecasting and risk adjustment, the explanation must be found in the risk adjustment. The standard model must be risk adjusting too much such that the error in forecasting is more than offset. Indeed, considering the CCAPM model, it is clear that investors are much more conservative in their risk adjustment than indicated by the standard model. Instead of using analyst's forecasts of 3-5 year growth, I can assume zero growth together with a negative growth rate in the terminal value and obtain substantially better valuation and investment performance than in the standard model. This clearly suggests that investors are both conservative in their assumptions about future value creation and risk adjustment. These results are in strong support of what Stephen H. Penman calls the *wisdom, distilled from practice of fundamental analysis over the years* when he writes[4]

Don't mix what you know with speculation. Anchor a valuation on what you know rather than speculation. Beware of paying too much for growth.

The standard model violates this since it requires unreasonably large growth rates. This is corrected by applying the CCAPM model which suggests that the investor to a large extend is willing to pay for short-term value creation but not too much for uncertain future growth. Further, since the investor is quite certain about near term value creation, he/she uses mild discounting for risk.

A robustness analysis shows that while analysts' forecasts of long-term growth are too optimistic, they still contain valuable information if used correctly. In the standard model, the information seems to be contaminated by noise in the measure of cost of equity. The CCAPM model does not contaminate the forecasts with such noise, and including the forecasts

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[4]See Penman (2009), chapter 1.

in the CCAPM model improves performance even further. The robustness analysis also shows that historical factor risk premia, used in the standard models, must be calculated using a geometric mean rather than arithmetic mean to yield sufficiently low risk premia. Further, if a linear relationship between model implied pricing errors and future returns is assumed, then the CCAPM valuation model significantly outperforms the standard model, as seen by the Vuong (1989) likelihood ratio test for relative performance of non-nested models.

The empirical analysis uses companies traded on either AMEX, NYSE or NASDAQ from 1982 to 2008 with stock return data in CRSP, accounting data in Compustat, and earnings forecasts in I/B/E/S.

The paper is related to Nekrasov and Shroff (2009) who derive a factor model for risk adjustment based on accounting betas and perform a large scale empirical study which shows that their model is able to outperform the classical CAPM in terms of absolute valuation errors. However, their model implementation is even more data hungry than the standard CAPM and FF based models. Additionally, it implies a constant term structure of risk adjustment. The paper is further related to the general literature on risk measurement such as Chan and Chen (1991) and Fama and French (1992) who argue that the book to price ratio is a determinant of distress risk. It is also related to Fama and French (1993) and Fama and French (1996) who argue that the book-to-price, size, and market betas are important determinants of equity risk.[5] The only persistent factor is the market factor, implying that the other factors might not be properly linked to the fundamentals of value generation. Confirming the results in Nekrasov and Shroff (2009) and Jorgensen et al. (2011), the results in this paper show that while the SMB and HML factors may help explaining short-term returns, they seem to have little success explaining fundamental company value when included in the discount factor. The results of this paper also support Nekrasov and Shroff (2009) and Nekrasov (2011) in the sense that risk of operations are explained better by important accounting variables than by the usual Fama-French factors.

This paper contributes to the literature in several ways. First, it supports the theoretical accounting literature, providing empirical evidence that risk adjustment, based on fundamental asset pricing theory, is relevant not just from a theoretical point of view but also in practice. Second, it provides practical guidelines for implementation of valuation models based on time

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[5]More recent empirical evidence suggests that the book to price ratio and size factors might not be as important determinants of equity risk as initially implied (see e.g. Berk (1995), Loughran (1997), Howton and Peterson (1998), Horowitz et al. (2000) and Chou et al. (2004)).

series econometrics and discounting for risk in the numerator. The literature has mostly focused on implementation of different versions of the standard valuation model, while this paper expands the set of practically implementable valuation models. Third, it provides an investment based framework for comparing valuation models instead of the standard approach of simply comparing the values predicted by the model with the values observed in the market. Fourth, it provides empirical evidence that investors care about the relatively certain near term value generation rather than much more uncertain long-term value creation. As a result, a very conservative estimate of long-term growth is sufficient to describe the level of stock prices. Lastly, the paper contributes to the literature on investor preferences and risk pricing by showing that investors are very conservative in their risk adjustment.

The remainder of the paper is organized as follows. Section 2 presents the standard and CCAPM valuation models. Section 3 describes the data sources and sampling method. Section 4 describes the implementation method of the valuation models. Results are presented in Section 5. Various robustness checks are performed in Section 6, and Section 7 concludes.

2   Valuation Models

In this section I present the two valuation models and show how they are based on classical asset pricing theory. In both models the accounting is similar since they discount forecasted residual income. The difference between the models lies in how they discount for risk. In the standard model discounting for risk is done in the denominator through a CAPM-based discount factor. The CCAPM model differs from this in three important ways. First, a closed-form expression for the risk adjustment is derived from assumptions about the time series properties of residual income return. Secondly, utilizing an important asset pricing result shown in Rubinstein (1976), discounting for risk is done in the numerator. Thirdly, the model disentangles discounting for risk and timing of forecasted residual income which provides clear intuition about the relative importance of each of these individually important quantities.

2.1   Standard Asset Pricing Literature

Let the uncertainty and homogeneous preferences of investors be represented by the standard probability space (Ω, Ξ, Φ). Assuming no arbitrage and mild regularity conditions, a strictly positive state-price deflator (SPD) m exists such that the price at time t, V_t, of any asset in

the economy is given by

$$V_t = \sum_{\tau=1}^{\infty} \mathrm{E}_t \left[m_{t,t+\tau} d_{t+\tau} \right],$$

where d is the dividend from the asset. The SPD discounts both for risk and time of dividends. As shown in Rubinstein (1976), an alternative representation of the price separates the adjustment for time from the adjustment for risk as

$$V_t = \sum_{\tau=1}^{\infty} B_{t.t+\tau} \left[\mathrm{E}_t \left[d_{t+\tau} \right] + \mathrm{Cov}_t \left(d_{t+\tau}, Q_{t,t+\tau} \right) \right], \tag{1}$$

where $B_{t,t+\tau} = \left(1 + r^f_{t,t+\tau} \right)^{-1} = \mathrm{E}_t \left[m_{t,t+\tau} \right]$ is the date t price of a risk-less asset paying one dollar at date $t+\tau$, and $Q_{t,t+\tau} = \frac{m_{t,t+\tau}}{B_{t,t+\tau}}$ is the so called valuation index often used in the accounting literature (see, e.g., Feltham and Ohlson (1999) and Christensen and Feltham (2003)). Risk adjustment is perceived to be one of the hardest parts of corporate valuation. To address this, further assumptions on the SPD are needed. The models take different practical approaches to tackle this problem.

2.2   Standard CAPM Based Valuation Model

The CAPM is a single-period theory, and it can be derived in several ways. One way is to assume that dividends on all assets are simultaneously normal, and then apply Stein's lemma to rewrite the single-period equivalent to (1) as

$$V_t = B_{t.t+1} \left\{ \mathrm{E}_t \left[d_{t+1} \right] + \mathrm{E}_t \left[Q' \left(d^M_{t+1} \right) \right] \mathrm{Cov}_t \left(d^M_{t+1}, d_{t+1} \right) \right\}, \tag{2}$$

where d^M is the dividend of the market. Since this formula prices any asset, and therefore also the market asset, it is straightforward to show that the expected return R of any asset is given by

$$\mathrm{E}_t \left[R_{t+1} \right] = r^f_{t,t+1} + \left(\mathrm{E}_t \left[R^M_{t+1} \right] - r^f_{t,t+1} \right) \frac{\mathrm{Cov}_t \left(R^M_{t+1}, R_{t+1} \right)}{\mathrm{Var}_t \left(R^M_{t+1} \right)} \tag{3}$$

$$= r^f_{t,t+1} + rp_{t,t+1},$$

where R^M is the return on the market portfolio. $\frac{\mathrm{Cov} \left(R^M, R \right)}{\mathrm{Var} \left(R^M \right)}$ is commonly referred to as the company beta if R is the return on a company stock. This equation states that covariance

between the market and an asset determines the risk premium of the asset. If an asset has high returns in periods where the market has low returns, then the asset has lower expected return, implying higher asset value.

To calculate the expected return via (3) one has to calculate the company beta and the expected excess return on the market. Section 4.1 describes the methods used for these calculations. To find the value of the company, using the CAPM method, it is commonly assumed that the beta and excess return on the market remain constant. I also take this approach, and I further assume a constant risk-free rate. These are similar assumptions to those in Nekrasov and Shroff (2009) and Jorgensen et al. (2011). With these assumptions the standard valuation model can be formulated as

$$V_t = \sum_{\tau=1}^{\infty} \frac{\mathrm{E}_t\left[d_{t+\tau}\right]}{\left(1 + r^f + rp\right)^{\tau}}. \tag{4}$$

This is the standard dividend discount model (DDM) stating that the value of any asset is calculated as the sum of expected future dividends discounted by the cost of equity.

Perhaps the most important criticism of the DDM, as regards to valuation, is that while a dividend payment in effect gives the investor a dollar amount it is not necessary an indication of value generation by the firm. A firm could in principle borrow money to pay dividends. Miller and Modigliani (1961) show that such a financing decision does not generate value.[6] The so called residual income (RI) valuation (RIV) model discloses value generation in a more tractable fashion and is therefore often preferred in corporate valuation. As shown in Feltham and Ohlson (1995). the RI model yields the same valuation as the DDM if the accounting system satisfies the clean surplus relation (CSR)

$$bv_t = bv_{t-1} + ni_t - d_t, \tag{5}$$

where bv is book value of equity, ni is net income and d is the dividend. That is, besides dividend payments all changes in book value of equity must be recorded in net income. Defining residual income as $ri_t = ni_t - \left(r^f + rp\right) bv_{t-1}$, it is easily shown that when the clean surplus relation is satisfied the DDM in (4) can be rewritten as the RI model

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[6]The general perception in the market seems to be in accordance with this result. However, the litterature has argued that the value could be affected for several reasons. There could be a positive tax shield effect, as shown in e.g. Modigliani and Merton (1963), Fernandez (2004) and Cooper and Nyborg (2006), or a positive signaling effect (see e.g. Miller and Rock (1985), Ofer and Siegel (1987), and Brook et al. (1998)). A possible negative effect is the leverage effect (see e.g. Gordon (1989)).

$$V_t = bv_t + \sum_{\tau=1}^{\infty} \frac{\mathrm{E}_t\left[ri_{t+\tau}\right]}{\left(1 + r^f + rp\right)^{\tau}}. \tag{6}$$

From this equation it is seen that the value of the company is the sum of book value of equity and future expected residual income discounted using the cost of equity.

The practical considerations involved in calculating the value of common shareholders equity, using (6), will be discussed and explained in detail in Section 4.1.

2.3 CCAPM valuation model

As for the standard model in (6), I base the CCAPM model on the CSR and use RI. However, instead of adjusting RI for both risk and time trough the discount factor in the denominator, I first make assumptions about the time series properties of residual income return and consumption to obtain a closed-form expression for the risk adjustment. Secondly, forecasted RI is adjusted for risk in the numerator and finally risk adjusted RI is discounted by the risk-free rate. Assuming the CSR (5) holds, it follows from (1) that the price of any asset can be represented as

$$V_t = bv_t + \sum_{\tau=1}^{\infty} B_{t.t+\tau}\left[\mathrm{E}_t\left[ri_{t+\tau}\right] + \mathrm{Cov}_t\left(ri_{t+\tau}, Q_{t,t+\tau}\right)\right]. \tag{7}$$

This equation prices all assets, but further assumptions are needed for the equation to be implementable in practice. One can proceed from this equation in various ways. As in Nekrasov and Shroff (2009), one can risk adjust residual income utilizing accounting data in a factor-model approach. In their model they use 10 years of historical accounting data to calculate a constant risk adjustment term. Naturally, this places strong assumptions on both the data (many consecutive years of data) and the theoretical foundation of the model (e.g. constant risk adjustment). I take a different approach and place assumptions on the time series properties of residual income return $\mathrm{Re}\,BV$ and the consumption index ci and obtain an explicit solution of the risk adjustment term $\mathrm{Cov}(\mathrm{Re}\,BV, ci)$ which will be time varying.

Let ci denote a consumption index containing both the information in real aggregate consumption and the price level in the economy.[7] I assume investors have standard power utility $u\left(c\right) = \frac{1}{1-\gamma}c^{1-\gamma}$, where γ is the Arrow-Pratt measure of relative risk aversion and c is the real consumption. It is also assumed that a Pareto efficient equilibrium exists. Under the further

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[7]With standard power utility the consumption index is the product of relative risk aversion and aggregate consumption per capita plus the price index.

assumption of future residual income and the consumption index being jointly normal, CF shows that (7) can be reformulated as

$$\frac{V_t}{bv_t} = 1 + \sum_{\tau=1}^{\infty} B_{t,t+\tau} \left[\mathrm{E}_t \left(\mathrm{Re}\, BV_{t,t+\tau} \right) - \mathrm{Cov}_t \left(\mathrm{Re}\, BV_{t,t+\tau}, ci_{t+\tau} \right) \right], \tag{8}$$

where $\mathrm{Re}\, BV_{t,t+\tau} = \frac{ri_{t+\tau}}{bv_t}$, $ri_{t+\tau} = ni_{t+\tau} - r_{1y}^f bv_{t+\tau-1}$, $ci_{t+\tau} = ci_{t+\tau}^R + \ln(p_{t+\tau}) = \gamma \ln(c_{t+\tau}) + \ln(p_{t+\tau})$ and p is a price index. The consumption index is easily calculated from observed data and an assumption about γ as will be shown in Section 4.2.

Following CF, I assume a simple first order autoregressive model for $\mathrm{Re}\, BV$ given by

$$\mathrm{Re}\, BV_{t,t+\tau} - \mathrm{Re}\, BV_t^o (1+\mu)^\tau = \omega_r \left(\mathrm{Re}\, BV_{t,t+\tau-1} - \mathrm{Re}\, BV_t^o (1+\mu)^{\tau-1} \right) + (1+\mu)^\tau \varepsilon_{t+\tau}. \tag{9}$$

Here $\mathrm{Re}\, BV_t^o$ is the structural level of residual income return at the valuation date t, μ is the growth rate of the structural level of residual income return, and ω_r is the first order autoregressive parameter determining the speed of convergence to the structural level of residual income return. In the innovation specification of the equation, I introduce a heteroschedastic term to take account of plausibly larger(smaller) variation in errors when the residual income return is higher(lower). The motivation behind assuming an autoregressive process with mean reversion towards a deterministic trend is inspired by, for example, Penman (2009) and Koller et al. (2005) who argue that, in practice, it is often assumed that competition drives residual income towards a structural level, for example, an industry average, or alternatively towards zero.

I assume that the consumption index ci follows the simple process

$$ci_{t+\tau} - ci_{t+\tau-1} = g + \delta_{t+\tau}, \tag{10}$$

which is fully consistent with the standard asset pricing assumption of aggregate consumption being log-normally distributed.[8] The constant growth rate further implies constant interest rates. The innovations in the above equations, ε and δ, are assumed serially uncorrelated and

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[8] The nominal consumption index is given by $ci_{t+\tau} = ci_{t+\tau}^R + \ln(p_{t+\tau})$, where $ci_{t+\tau}^R = \gamma \ln(c_{t+\tau})$, and c is the real aggregated consumption per capita. That is, if I assume that ci is normally distributed, I implicitly assume that c is log-normally distributed.

can be written as

$$\begin{bmatrix} \varepsilon_{t+\tau} \\ \delta_{t+\tau} \end{bmatrix} \sim N \left(\mathbf{0}, \ \begin{matrix} \sigma_r^2 & \sigma_{ra} \\ \sigma_{ra} & \sigma_a^2 \end{matrix} \right).$$

That is, I allow for ε and δ to be contemporaneously correlated to accommodate a potential dependence between $\mathrm{Re}\,BV$ and ci.

Solving equations (9) and (10) recursively yields

$$\mathrm{Re}\,BV_{t,t+\tau} = \mathrm{Re}\,BV_t^o \left(1+\mu\right)^\tau + \omega_r^\tau \left(\mathrm{Re}\,BV_{t,t} - \mathrm{Re}\,BV_t^o\right) + \sum_{s=0}^{\tau-1} \left(1+\mu\right)^{\tau-s} \omega_r^s \varepsilon_{t+\tau-s}, \qquad (11)$$

$$ci_{t+\tau} = ci_t + \tau g + \sum_{s=0}^{\tau-1} \delta_{t+\tau-s}. \qquad (12)$$

From the equation for $\mathrm{Re}\,BV$ (11) it follows that[9]

$$\mathrm{E}_t\left[\mathrm{Re}\,BV_{t,t+\tau}\right] = \mathrm{Re}\,BV_t^o \left(1+\mu\right)^\tau + \omega_r^\tau \left(\mathrm{Re}\,BV_{t,t} - \mathrm{Re}\,BV_t^o\right), \qquad (13)$$

$$\mathrm{Var}_t\left[\mathrm{Re}\,BV_{t,t+\tau}\right] = \sigma_r^2 \left(1+\mu\right)^{2\tau} \frac{1 - \left(\frac{\omega_r}{1+\mu}\right)^{2\tau}}{1 - \left(\frac{\omega_r}{1+\mu}\right)^2}. \qquad (14)$$

For the consumption index (12) it similarly follows that

$$\mathrm{E}_t\left[ci_{t+\tau}\right] = ci_t + \tau g,$$

$$\mathrm{Var}_t\left[ci_{t+\tau}\right] = \tau \sigma_a^2.$$

Furthermore the covariance between the two series is given by

$$\mathrm{Cov}_t\left(\mathrm{Re}\,BV_{t,t+\tau}, ci_{t+\tau}\right) = \sigma_{ra} \left(1+\mu\right) \frac{\left(1+\mu\right)^\tau - \omega_r^\tau}{1 + \mu - \omega_r}. \qquad (15)$$

That is, the risk adjustment is determined by the covariance between the residual income return $\mathrm{Re}\,BV$ and the consumption index ci. The higher covariance, the higher is the adjustment for risk, since the asset provides a less valuable hedge against periods with low consumption. The risk adjustment also depends on the growth rate of the structural level of residual income return and in the appendix it is shown that the risk adjustment is increasing in the growth rate if $\sigma_{ra} > 0$. This is intuitively clear since if $\sigma_{ra} > 0$ the company provides no hedging value and

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[9]See appendix for details of the calculations in this section.

a higher growth rate in residual income return means that higher values of residual income return have to be risk adjusted.[10] For $\sigma_{ra} > 0$, $\mu > 0$, $\omega_r > 0$ and $\tau > 1$ the risk adjustment is increasing in ω_r. That is, the slower the reversion to the long run structural level, the higher the risk adjustment. This is again an intuitive result since ε becomes relatively more important if mean reversion is slow. The covariance (risk adjustment) is converging towards growing at a rate of μ. The speed of convergence towards this growth rate is constant in σ_{ra}, increasing in μ, and decreasing in ω_r.

It is also seen that if $\omega_r = 0$ (instant mean reversion) then the risk adjustment is given by

$$Cov_t \left(\operatorname{Re} BV_{t,t+\tau}, ci_{t+\tau} \right) = \sigma_{ra} \left(1 + \mu \right)^{\tau}. \tag{16}$$

This result is different from the result obtained in CF where the risk adjustment was solely determined by σ_{ra} and independent of both μ and τ. Equation (16) implies that the risk adjustment in this simplified case with instant mean reversion in residual income return is still determined by the growth in the structural level of residual income return and the risk adjustment is non-flat. This result comes from the assumption on the innovations in (9) and reflects the fact that in nominal terms the uncertainty about the return on equity is increased when the structural level of residual income return is increased.

One of the major criticisms of the standard model is that it is discounting future earnings by a constant cost of equity. Ang and Liu (2004) emphasize that this is not a reasonable assumption, and as is seen from (15) the CCAPM model has time varying discounting for risk.

Further assumptions are needed for the model to be implemented in practice. These will be described in Section 4.2.

3   Data and Sampling

Having set the theoretical frame of the valuation, this section describes the data needed for valuation using the standard approach (described in Section 2.2) and the CCAPM model (described in Section 2.3).

I use analyst's one and two year consensus forecasts from the month of April which is available trough the I/B/E/S database.[11] Applying analysts' forecasts of the long-term growth

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[10] Naturally, the net effect of an increase in the growth rate on company value will be positive if $\operatorname{Re} BV_t^o > 0$. It is only the isolated effect on the risk adjustment which will contribute negatively to the value of the company.

[11] The I/B/E/S manual states that consensus forecasts only contain the most resent analyst forecasts. This

Table 1: Data sorting steps and effects on the number of companies in the sample

Sorting step and sorting criterion	# companies left
1: Tickers in I/B/E/S with either 1 or 2 year or LTG forecasts	16,918
2: Sort out all forecasts not done in April	16,067
3: Sort out all forecasts of non-December earnings	14,765
4: Sort out all consensus estimates based on < 3 analysts	9,658
5: Linking to Compustat and CRSP	8,262
6: Sort out all non AMEX/NYSE/NASDAQ	8,257
7: Require both 1 and 2 year forecasts	5,175
8: Require 1, 2 and LTG forecasts	3,377
9: Delete companies with invalid IBCOM (net income)	3,367
10: Companies with positive CSE	3,335
11: Non-financial and non-utility	2,526

Note: The table takes the I/B/E/S database as starting point and then sorts out companies based on the listed criterions. The number of companies in the sample is measured by the number of distinct I/B/E/S tickers. The cibeslink macro available trough WRDS is used to link I/B/E/S and Compustat databases. The iclink macro available trough WRDS provides the link to the CRSP dataset. Utilities are defined as companies with SIC codes 4900-4949 and financial firms as companies with SIC codes 6000-6999.

(LTG) rate to the two year forecast, I calculate $3-5$ year ahead earnings forecasts. The I/B/E/S database contains April earnings per share (EPS) forecasts for 16,918 US companies (see Table 1). By applying forecasts from the month of April all companies with financial year following the calender year are expected to have made their annual financial report public at the time of the forecast. This mitigates information asymmetry between traders. Furthermore, analysts often update their earnings forecasts after the release of an annual report, to reflect their updated information. Thus, April earnings forecasts are expected to be relatively more updated than earnings forecasts in other months of the year. The financial year of most companies follows the calendar year and I only keep these in the sample. As argued by Nekrasov and Shroff (2009) this ensures that betas and priced risk measures are estimated at the same point in time each year and the analysis is simplified. Table 1 shows the effect of sampling on the number of distinct tickers/companies available in the analysis.

To ensure a sufficient quality of the consensus EPS forecasts I exclude median forecasts based on less than three analysts. This approach is not standard in the literature and reduces the number of distinct companies in the sample to 9,658 (see Table 1) which is a relatively large reduction in the sample size. However, consensus estimates have little meaning if they are based on less than three estimates.

The three databases use different unique tickers for the companies and none of these provide

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should mitigate the risk of having outdated forecasts. Alternatively the detailed files contain date stamp of earnings forecasts. However, this file does not track all analysts. Thus, while using the detailed datafile would allow me to set specific criterion on for example age of forecasts, it also limits the number of analyst forecasts significantly.

the link to the tickers used in the other databases. Therefore, a link between these databases is constructed based on the cibeslink macro to link I/B/E/S to Compustat and the iclink macro to link I/B/E/S to CRSP.[12],[13] Since the link between databases is not perfect and/or since there are differences in the variety of companies in the different databases, the sample size is reduced to 8,262 companies (see Table 1).

Most companies in the dataset are traded on the major stock exchanges (AMEX, NYSE and NASDAQ). I exclude companies not traded on these exchanges.

As will be shown later, the standard model is highly dependent on the estimates of LTG. Therefore I need both 1-2 year earnings forecasts as well as the LTG rate at the time of the valuation. If one of these forecasts is unavailable at a valuation date, I exclude that observation from the sample. As is seen from Table 1 this reduces the sample dramatically to 3,377 companies, yielding 20,499 distinct firm-year observations.

As in Fama and French (2001) I exclude utility (SIC codes 4900-4949) and financial firms (SIC codes 6000-6999), limiting the analysis to 14,220 firm valuation dates and 2,526 distinct firm tickers spanning the period from 1982 to 2008, i.e., roughly 5.6 observations per company/ticker.

The end of year book value of common equity (CSE) (Compustat item #60), net income before extraordinary items (net income/IBCOM) (Compustat item #237), dividends paid to common equity (Compustat item #21) and total assets (Compustat item #6) are from the Compustat database. The stock price (CRSP variable PRC) and shares outstanding (CRSP variable SHROUT) are from the CRSP daily database. Betas for each company in each year are estimated using monthly excess stock returns (CRSP) and monthly excess returns on the 3 Fama-French (FF) factors (from the Fama-French database).[14] The method is briefly described in Section 4.1. Following Nekrasov and Shroff (2009) I use a 60 month sample for each calculation whenever such data is available from CRSP. If 60 months of data is not available, I allow for a minimum of 36 months. As seen from Table 2, for most observations beta is calculated using 60 observations and 2,084 observations were excluded from the valuation due to lack of data. Precisely this need for data in the standard valuation model is an often used explanation

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[12] These macros are available trough WRDS. To link the databases to eachother I use the IDUSM dataset from I/B/E/S and the STOCKNAMES dataset from CRSP.

[13] The linking quality between I/B/E/S and CRSP is based on a score from 0 to 6, where 0 is the best match. I do not accept scores above 1 which should ensure that I only keep correctly matched firms. A small fraction of the I/B/E/S tickers have multiple links to CRSP tickers. In these cases I only keep the company if it has a linking score of 0 and the score is unique.

[14] The returns are in excess over the 1 month Treasury rate.

Table 2: Beta calculation effect on companies in sample

Criterion:	No. observations
Using 60 observations	10,752
Using 36 observations	1,384
Not calculated due to 1-36 observations	2,084

Note: The table shows the number of observations for which 60 and 36 months of data are used, as well as the number of observations for which there was less than 36 months of data. Betas are calculated based on monthly excess returns on the security and the value weighted NYSE-AMEX-NASDAQ portfolio, high minus low and small minus big portfolios.

why multiples analysis is so popular in practice. Following the same approach, betas are also calculated using the FF 3 factor approach. After calculation of betas the sample size is limited to $12,136$ valuations on $1,938$ distinct companies. Contrary to Nekrasov and Shroff (2009) I do not include the April return of the valuation year since the valuation is performed around mid month and I do not allow the use of unrealized information in my valuations. This is mostly a choice of consistency rather than a choice of real effect.

For the calculation of betas I use the one month Treasury as the risk-free rate and, as is standard in both practice and the literature, I use 10 year treasury for discounting future residual income. It is relatively straight forward to use the observed yield curve for discounting at each valuation date, but this is not standard in the valuation literature. Chis choice is unlikely to bias the results in favor of any of the models of interest, and it simplifies analysis.

A number of observations are deleted during the valuation process using the CCAPM valuation model, as will be described in Section 4.2. Thus, the results reported in the results section are calculated using $9,953$ valuations on $1,822$ distinct companies. This is fewer valuations compared to valuation papers such as Nekrasov and Shroff (2009) and Jorgensen et al. (2011). There are several reasons for this. 1: I include only non-financial and non-utility in the sample. 2: I require each valuation to have both a 1 year and 2 year forecast as well as a forecast of LTG. 3: I do not include consensus forecasts based on less than 3 analysts' forecast. 4: Unlike Jorgensen et al. (2011) I require 36 observations in the calculation of betas. 5: Additional sampling must be done to apply two distinct valuation models and not just the standard model as in Jorgensen et al. (2011). The points 1-3 each reduce the sample significantly as seen from Table 1, while point 4 has only minor effect, as implied by Table 2. As mentioned above, the sampling choices are made to make the analysis as realistic and precise as possible. As a robustness check I also perform the analysis relaxing the criterion in point 1 and show that inclusion of financial and utility has no effect on the conclusions. Further, robustness checks show that the CCAPM model fares very well both with and without LTG.

Table 3: Data requirements for the standard model, CCAPM model and simple forward earnings multiple based valuation model.

Data:	Standard	CCAPM	Multiples
1 month Treasury	x	-	-
10 year Treasury	x	x	-
Compustat	x	x	x
I/B/E/S	x	x	x
CRSP	x	-	-
Fama-French	x	-	-
NIPA	-	x	-

Note: If the data is required, it is marked with x, and if not required, with -.

In the CCAPM valuation model I need data on real consumption as well as on the price index. The consumption data is the usual series used in the CCAPM literature. It is obtained from the NIPA tables available from Bureau of Economic Analysis. The price index is also available from the NIPA tables. Details on calculation of the consumption index will be given in Section 4.2.

Table 3 shows the data requirements for the two models, and it is clear that the CCAPM model requires less data than the standard valuation model. It is primarily the calculation of betas in the standard model which requires a lot of historical data. Calculating betas requires the historical return series for the stock of interest, and these are only available if the stock has been traded for a substantial historical period.[15] While, both the standard model and the CCAPM model require I/B/E/S data, it will become apparent later that the standard model depends much more on LTG estimates than the CCAPM model. The only data needed for the CCAPM model compared to the standard model is the NIPA data, but this is no real limitation since it is available from 1930 on an annual frequency and since 1952 on a quarterly frequency.[16] Both models require much more data compared to a simple foreward earnings multiple based valuation. Such an analysis only requires the most recent accounting data and the 1 year ahead earnings forecast.

4 Valuation Procedure

This section describes how the valuation models are implemented in practice. Both models require a long list of practical choices and the results can change a lot depending on these. As

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[15] In practice many suggestions have been made as to how to solve this problem. For example one can use betas from comparison firms or accounting betas if these are available.

[16] Although the data is available since 1930, the quality is certainly not as good as for return data in CRSP.

a consequence, I will perform the valuation based on several different assumptions, for instance about the growth rate in the terminal value and about the factor risk premium estimation. While the standard model places stronger requirements on data availability, it is practically simpler to implement than the CCAPM model. The practical decisions involved when applying the standard model are well explained in the literature, and therefore I will only briefly explain how I implement this model. I will be much more detailed in describing how to implement the CCAPM model since the current literature has very little to offer on this, and since it is harder to implement.

4.1 Standard Model Procedure

The standard valuation model cast in the residual income framework is the equation (4)

$$V_t = bv_t + \sum_{\tau=1}^{\infty} \frac{\mathrm{E}_t \left[ri_{t+\tau} \right]}{(1 + r^f + rp)^{\tau}}. \tag{17}$$

While the valuation equation looks very simple, it is still widely debated how to implement it in practice. The valuation equation requires forecasting of residual income and calculation of the discount factor which takes account of both discounting for time and risk. I discuss these elements in turn. Further, the model, as it stands in (17), includes an infinite sum. Since forecasting into the infinite horizon is not practically feasible, a truncation point is chosen, and a terminal value is calculated. I will conclude this section with explaining the practical considerations involved.

4.1.1 Discounting for Time and Risk

Discounting for time and risk is done in the denominator by a discount factor called the cost of equity. Calculating the cost of equity $1 + r^f + rp$ can be done in several different ways. In this paper I calculate it using

$$r^f + rp = r^f_{10y} + \beta \cdot RP,$$

where r^f_{10y} is the 10 year Treasury yield, β is a vector of factor sensitivities, and RP is a vector of factor risk premia. I estimate betas at each valuation time for each firm using up to 60 observations of monthly data in the regression

$$\mathrm{E} \left[R \right] - r^f_{1m} = a + \beta_{MKT} R^M + \beta_{SMB} R^{SMB} + \beta_{HML} R^{HML} + \varepsilon, \tag{18}$$

Table 4: Cost of equity methods

Factors \ Years	5	10	20	30	1926-
1 Factor	1F,5Y	1F,10Y	1F,20Y	1F,30Y	1F,ALL
3 Factor	3F,5Y	3F,10Y	3F,20Y	3F,30Y	3F,ALL

Note: Combinations of assumptions made about the cost of equity in the standard analysis. Rows show the number of factors and columns the number of years of data used when calculating factor risk premia.

where r_{1m}^f is the 1 month Treasury yield, $E[R]$ is the return on the asset of interest, R^M is excess return on the market, R^{SMB} is excess return on the FF small minus big portfolio and R^{HML} is excess return on the FF high minus low portfolio. I run this equation both including only the market factor (i.e., assuming $\beta_{SMB} = \beta_{HML} = 0$) and all three factors.

The results for betas obtained from this equation are used to calculate the cost of equity as (when using all three factors)

$$r^f + rp = r_{10y}^f + \beta_{MKT}RP^M + \beta_{SMB}RP^{SMB} + \beta_{HML}RP^{HML},$$

where RP^M, RP^{SMB} and RP^{HML} are the historical risk premium on the market, small minus big, and high minus low portfolios, respectively.[17] I calculate RP^M, RP^{SMB} and RP^{HML} as the geometric average over the rolling windows of 5, 10, 20 and 30 years preceding the estimation day as well as the full period from 1926 until the month preceding the estimation day.[18] As summarized in Table 4, I obtain 10 different measures for the cost of equity for each firm at each valuation date.

In very rare cases the cost of equity is below 2%, and I truncate it to 2%. This truncation has effect more often in the 3 factor than in the 1 factor case, and more so using few observations in the calculation of risk premia than when many observations are used.

Table 5 shows descriptive statistics of the estimated beta values. As expected, the market portfolio has both a mean and a median of roughly 1. Even though betas on the SMB and HML portfolios are, in general, not as large, at least the SMB factor still seems to have some explanatory power with the expected positive sign. The betas on the market and small minus big portfolios are positively skewed, while betas on the high minus low portfolio is negatively skewed, reflecting a fat lower tail, which is also seen from the quantiles.

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[17]The cost of capital is calculated using monthly data, and then afterwards annualized.

[18]In the robustness analysis, I also analyse the performance of the standard model, when using the aritmetric average rather than the geometric average in the calculation of risk premia.

Table 5: Descriptive statistics of betas

Descriptive statistic	1 Factor	FF mkt	FF smb	FF hml
Mean	1.166	1.134	0.437	0.035
Median	1.069	1.078	0.339	0.128
Standard deviation	0.683	0.597	0.792	1.002
Skewness	1.516	0.895	0.794	-0.849
Kurtosis	8.113	6.611	4.873	6.066
Quantiles:				
100% Maximum	7.406	5.897	5.489	5.436
98%	3.093	2.664	2.420	1.850
95%	2.426	2.179	1.881	1.429
75%	1.438	1.423	0.866	0.652
25%	0.737	0.781	-0.076	-0.454
5%	0.292	0.293	-0.685	-1.740
2%	0.097	0.051	-0.941	-2.529
0% Minimum	-1.820	-2.427	-3.575	-7.062

Note: Descriptive statistics of estimated beta values. The second column reports descriptive statistics when using the market portfolio as the only factor. Columns 3-5 report descriptive statistics when using the three FF portfolios as risk factors.

4.1.2 Forecasting Book Value of Equity and Residual Income

The standard valuation model in (17) requires forecasts of residual income ri. To obtain these forecasts I use the most recent book value of equity which is calculated from accounting data for the previous year. Following Nissim and Penman (2001), I calculate CSE as

$$\text{Common shareholder equity (CSE)} = \text{Common equity (\#60)} \tag{19}$$
$$+ \text{ Preferred treasury stock (\#227) - Preferred dividends in areas (\#242).}$$

To forecast residual income I use analysts' estimates of five years forecasts of net income ni from the I/B/E/S database. Residual income for the first forecast year can then be calculated directly from the residual income formula $ri_t = ni_t - \left(r^f + rp\right) bv_{t-1}$. Since the book value of equity is unknown at future dates, I follow the standard practice in the literature (see, e.g., Frankel and Lee (1998), Claus and Thomas (2001), Gebhardt et al. (2001) and Easton (2002)) and forecast this value trough the CSR (5) by assuming a constant payout ratio equal to the current payout ratio where I calculate the current payout ratio as

$$\frac{\text{Dividends Common/Ordinary (\#21)}}{\text{Income Before Extraordinary Items (\#237)}}. \tag{20}$$

If the firm has negative net income (#237), I calculate the payout ratio by dividing current dividends with 6 percent of total assets (#6) - the historical payout ratio. If the current payout ratio is above 100 percent, I first try to calculate the payout ratio by dividing current dividends

with 6 percent of total assets. If this yields a payout ratio larger than 100 percent, I winsorize at 100 percent to ensure that the company does not liquidate itself. Naturally, liquidation is a valid strategy, but for valuation purpose allowing for liquidation will result in unwanted scenarios. As an example Lockheed Martin had more or less constant nominal dividend payouts during the years 2001-2003. In 2001 the net income was negative. In 2002 the net income was positive but small and the payout ratio is calculated to be 243, using equation (20). In 2003 net income was positive and relatively high resulting in a payout ratio of 37 percent. A payout ratio of 243 percent in 2002 will result in Lockheed Martin liquidating itself within the next few years, which is of course not realistic. The winsorization strategies are only used in few cases. In around 4 percent of the cases I calculate a payout ratio above 100 percent and divide dividends with 6 percent of total assets instead. In around 15 percent of these cases (i.e., less than 1 percent of all observations), I still obtain a payout ratio in excess of 100 percent, and I then winsorize at 100 percent. Since I only winsorize for few observations, it has little effect on median results.

Having a starting value for book value of equity forecasts of net income, and a constant payout ratio, one can forecast future book values of equity trough CSR (5). With the forecasted book value of equity, forecasted net income and a constant cost of equity, I forecast residual income five years ahead.

4.1.3 Terminal Value

The final element to handle in the valuation equation (17) is the infinite sum. I assume a truncation point and let values evolve according to a Gordon growth like formula. I follow Jorgensen et al. (2011) and make several different assumptions for the terminal values in the standard valuation model to accommodate for several of the suggestions made in the literature as how to calculate terminal values. The general formula used is given by

$$V_t = bv_t + \sum_{\tau=1}^{5} \frac{\mathrm{E}_t\left[ri_{t+\tau}\right]}{\left(1 + r^f + rp\right)^{\tau}} + \sum_{\tau=6}^{12} \frac{\mathrm{E}_t\left[ri_{t+\tau}\right]}{\left(1 + r^f + rp\right)^{\tau}} + \frac{1}{\left(1 + r^f + rp\right)^{12}} \frac{\mathrm{E}_t\left[ri_{t+12}\right]\left(1 + g\right)}{r^f + rp - g},$$

where g is the terminal growth rate. The third part of the above formula forecasts and discounts residual income from 6 to 12 periods ahead. I assume an intermediate convergence period from $6 - 12$ periods ahead where I let residual income converge to a given level, as described below. 12 periods ahead, I calculate a terminal value based on the residual income in period 12 and

an assumption about the growth in residual income hereafter.

The first approach is a no growth case (RIVC) where I assume that residual income remains constant after the explicit forecast period if $ri_5 > 0$ and assume $g = 0$ in the terminal value. If $ri_5 < 0$, I let residual income revert towards zero in the intermediate period and assume $g = 0$ in the terminal value. The second approach assumes that residual income grows 3 percent in both the intermediate period and the terminal term (RIVG) if $ri_5 > 0$ and otherwise lets it revert to zero. In the terminal value $g = 0.03$. The third approach assumes return on equity $\frac{ni}{bv}$ reverts to the historical industry average in the intermediate period and residual income remains constant after period 12 (RIVI). The industry definitions follow the FF Fama and French (1997) 48 industry specification. In the RIVI approach, I forecast residual income based on a growth rate, calculated such that the return on equity equals the historical average industry return on equity at time 12. If return on equity is non-positive at the valuation time a feasible growth rate cannot be calculated, for the company of interest, and I let return on equity revert linearly to the historical industry return on equity. In the terminal value, I assume $g = 0$. The details are shown in the appendix.

4.2   CCAPM Model Procedure

There are several approaches by which to implement the CCAPM valuation equation in Eq. (8)

$$\frac{V_t}{bv_t} = 1 + \sum_{\tau=1}^{\infty} B_{t,t+\tau} \left(\mathrm{E}_t \left(\mathrm{Re}\, BV_{t,t+\tau} \right) - \mathrm{Cov}_t \left(\mathrm{Re}\, BV_{t,t+\tau}, ci_{t+\tau} \right) \right). \tag{21}$$

Christensen and Feltham (2009) suggest using the information contained in the term structure of interest rates to derive parameters of the model. While this is a valid and appealing approach, it also leaves many open questions of how to implement it practically. Following their approach involves estimating 6 parameters in a non linear equation for the term structure. Hence the standard Nelson-Siegel model Nelson and Siegel (1987) or simple extensions of the Nelson-Siegel model like for example the model by Svensson (1994) cannot be applied to construct the term structure since these models have less than 6 parameters.

In this paper I take a different approach. I use historical consumption data to estimate the time series properties of the consumption index and use industry data to determine the time series properties of residual income return. The implementation of the model follows an 8 step procedure:

1. The risk-free discount rate B is assumed to be constant and simply determined by the 10 year treasury rate, as in the standard model. That is, for example for $\tau = 2$, $B_{t,t+2} = \frac{1}{\left(1+r^f_{10y}\right)^2}$.

2. Residual income can be forecasted $1 - 5$ years ahead, as in the standard model, using analysts forecasts. I choose only to use 1 and 2 year ahead forecasts in my implementation since, as will be apparent later, the forecasts of long-term growth are unreasonably optimistic. From these forecasts and the observed book value of equity bv, forecasted residual income return $\text{Re} \, BV$ is calculated for forecast years 1-2.

3. As in the standard model an intermediate period can be assumed. If LTG is used, this period is from forecast year 6 to 12. Otherwise it is from forecast year 3 to 12. I do not utilize long-term growth forecasts, and for simplicity I assume that ReBV remains constant in the intermediate period if $\text{Re} \, BV_{t,t+2} > 0$ or increases to 0 if $\text{Re} \, BV_{t,t+2} < 0$.[19]

4. Risk adjustment in (15) requires an estimate of σ_{ra}, i.e., the covariance between $\varepsilon_{t+\tau}$ in (9) and $\delta_{t+\tau}$ in (10). In this step I describe how to obtain the time series of $\varepsilon_{t+\tau}$ and step 5 describes how to obtain the time series of $\delta_{t+\tau}$. I estimate $\varepsilon_{t+\tau}$ at the industry level for each year using the first order autoregressive equation (omitting cross-section subscripts)

$$\text{Re} \, BV_{t,t+\tau} = \text{Re} \, BV_t^o \left(1 + \mu\right)^\tau + \omega_r \left(\text{Re} \, BV_{t,t+\tau-1} - \text{Re} \, BV_t^o \left(1 + \mu\right)^{\tau-1}\right) + \left(1 + \mu\right)^\tau \varepsilon_{t+\tau},$$

where the LHS is a time series of $\text{Re} \, BV$ form 10 years prior to the valuation date. There are three parameters to estimate in the equation, namely the industry intercept $\text{Re} \, BV_t^o$, growth in industry $\text{Re} \, BV$ μ, and industry mean reversion parameter ω_r. The regression is estimated as a simple panel data model for each industry at each valuation date. The error term from this regression is given by $\left(1 + \mu\right)^\tau \varepsilon_{t+\tau}$, and having estimated μ I can determine the time series of $\varepsilon_{t+\tau}$. In few cases convergence could not be reached, and in few cases $|\omega_r| \geq 1$. These are deleted from the sample.

5. I assume constant growth in the consumption index and use 10 years of data to estimate the consumption index equation (10)

$$ci_{t+\tau} - ci_{t+\tau-1} = g + \delta_{t+\tau},$$

This yields the time series of error terms δ. The consumption index is calculated from historical

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[19] Several other assumptions could be made. One could for example assume $ReBV$ converges to the industry level or $\text{Re} \, BV$ could be forecasted using equation (9) when the parameters of the equation have been estimated.

data as

$$ci_{t+\tau} = \gamma \ln(c) + \ln(p_{t+\tau}),$$

where $c = \left(\frac{c^N}{p^N} + \frac{c^S}{p^S}\right)/I$, with N and S denoting non-durables and services respectively, and I is the population. Furthermore, $p = \frac{c^N}{c^N+c^S}p^N + \frac{c^S}{c^S+c^N}p^S$, i.e., the weighted price index.[20] I assume $\gamma = 2$.[21]

6. With results from step 4-5, I calculate σ_{ra} as the simple historical covariance between ε and δ. Risk adjustment, for each industry, at each valuation date, is then calculated using the equation for risk adjustment (15)

$$Cov_t\left(\operatorname{Re}BV_{t,t+\tau}, ci_{t+\tau}\right) = \sigma_{ra}\left(\mu+1\right)^\tau \frac{1 - \left(\frac{\omega_r}{\mu+1}\right)^\tau}{1 - \frac{\omega_r}{\mu+1}}. \tag{22}$$

From this relation I mathematically require $\mu \neq -1$ and practically require $\mu > -1$.[22] The parameters of the risk adjustment are constant and need to be known at the valuation date. ω_r and μ are known from step 4 and will be industry and year specific parameters. Naturally, it would be preferable if they were firm specific. Yet, while obtaining firm specific parameters is in general possible (if the historical data is available), I do not take this approach here since I want to be able to value firms with no historical data and firms with limited historical (or abrupt) data. While σ_{ra} is constant for each valuation, the covariance 22 determining the risk adjustment will be time varying as suggested by both theoretical and empirical research.

7. Since ReBV and the risk adjustment will have different growth rates in the terminal value, two separate terminal terms are calculated. The terminal value for ReBV is given by the standard Gordon growth formula

$$TV_{\operatorname{Re}BV} = \frac{\operatorname{Re}BV_{t,t+12}\left(1+g\right)}{r^f_{10y} - g},$$

where g is, as for the standard model, a constant growth rate.

As mentioned in Section 2.3, the risk adjustment term converges towards growing at a rate of μ. Therefore, I calculate the terminal value for risk adjustment when it has converged sufficiently. By sufficiently I mean at the point where the growth rate is $\mu + 0.002$ which

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[20]Further details are in the appendix.

[21]This value is often used in the literature (see, e.g., Campbell and Cochrane (1999) and Wachter (2006)) and is of only of little importance for the results.

[22]In very few industries and years this is an issue. These are deleted from the sample.

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usually happens after relatively few years. If convergence is not reached within 60 years, I truncate the model, and calculate the terminal value using a growth rate of μ. This seemingly complex treatment of the terminal value does in fact not complicate the valuation, except computationally.

8. Finally, firm value is calculated by adding elements of the previous steps together in the valuation equation (21). These can be written out in more detail as

$$
\begin{aligned}
\frac{V_t}{bv_t} &= 1 + \sum_{\tau=1}^{2} \frac{\mathrm{E}_t\left(\mathrm{Re}\,BV_{t,t+\tau}\right)}{\left(1+r_{10y}^f\right)^\tau} + \sum_{\tau=3}^{12} \frac{\mathrm{E}_t\left(\mathrm{Re}\,BV_{t,t+\tau}\right)}{\left(1+r_{10y}^f\right)^\tau} + \frac{1}{\left(1+r_{10y}^f\right)^{12}} \frac{\mathrm{E}_t\left(\mathrm{Re}\,BV_{t,t+12}\right)(1+g)}{r_{10y}^f - g} \\
&+ \sum_{\tau=1}^{60} \frac{1}{\left(1+r_{10y}^f\right)^\tau} \sigma_{ra}\left(\mu+1\right)^\tau \frac{1-\left(\frac{\omega_r}{\mu+1}\right)^\tau}{1-\frac{\omega_r}{\mu+1}} + \frac{1}{\left(1+r_{10y}^f\right)^{60}} \frac{\mathrm{Cov}_t\left(\mathrm{Re}\,BV_{t,t+60}, ci_{t+60}\right)(1+\mu)}{r_{10y}^f - \mu},
\end{aligned}
$$

if a constant interest rate is assumed, explicit forecast period is 2 years, convergence (intermediate) period continues until period 12, and risk adjustment does not converge until the maximum possible truncation point (60 periods). If a firm value is estimated to be negative, it is deleted from the sample.

5 Empirical Results

To test the performance of the models in different dimensions, I test and present the empirical performance of the models in two different settings. The first method for performance assessment is to compare the model value with the market value. This approach of performance evaluation is interesting since the general perception among economists is that the market, in general, is relatively precise in pricing liquid assets. Furthermore, this is the standard performance metric in the literature. On the other hand, as mentioned in Penman (2009), assets could trade at far from their fair fundamental value for extended periods, but they will revert to their fundamental value. As a result, I also use the best performing (in terms of comparing with market values) standard model and the CCAPM model to consider the performance of a simple trading strategy. I divide assets into portfolios based on how much they are over- or undervalued by the market according to the models. If one model is better at identifying portfolios with undervalued stocks earning higher returns than portfolios with overvalued stocks, then the model is perceived to be better. Ex ante, it should be mentioned that even though a model is out-performing in one of the above mentioned tests, it might not out-perform in the

other. The results for the second test will only differ between models if companies are ranked differently, relative to the other companies, in terms of over- and undervaluation.

5.1 Comparing Model Values with Market Values

In Table 6 I report descriptive statistics of key variables used as input to the valuation models. The dataset is split into three 9 year sub-periods, and both mean and median measures are reported. Both mean and median price per share are decreasing trough the period and this pattern is opposite what is observed in Nekrasov and Shroff (2009). One explanation of this difference could be that Nekrasov and Shroff (2009) require each company to have 10 consecutive yearly observations, and this could potentially introduce a strong survivorship bias in the dataset. This explanation is further supported by the dividend payouts which are showing the same decreasing pattern as in Nekrasov and Shroff (2009), but are much smaller, compared to their reported values. All other variables show largely the same patterns and values as in Nekrasov and Shroff (2009). The book value per share and the book-to-market ratio have decreased since the eighties, reflecting the bull market over most of the two later sub-periods. The mean (median) dividend payout has been decreasing steadily trough the period from a high of 32.4 percent (31.9 percent) in the earliest sub-period to 14.9 percent (0 percent) in the latest sub-period. Since these payout ratios only include dividends in the classical sense and not other types of distributions to shareholders, e.g. buybacks, it is likely that much of this decrease can be explained by the documented increase in share buybacks.[23]

The mean return on equity is increasing trough the sample period, while the median is largely unchanged.[24,25] This pattern is matched relatively well by analysts' forecasts of return on equity for the subsequent one and two years. It is further noted that the long-term growth rate is increasing slightly for both mean and median trough the sampling period. Analyst's, in general, seem to be biased towards reporting too high growth rates. Naturally, the average growth rate in excess of 10 percent predicted for all sub periods cannot be realized in practice. While analysts expectations about the short-term are reasonably accurate (or moderately up-

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[23]A relative increase in share repurchase is documented in Dittmar (2000) for the period 1977-1996, and in Fama and French (2001) for the period 1978-1999.

[24]Beginning-of-year book value is not available for all companies since it requires accounting data from a year before the valuation date. Therefore ROE is reported using end-of-year book value.

[25]It has been shown (see Ciccone (2002)) that earnings management is more likely to take place in companies with negative earnings which might influence the reported ROE numbers. However, due to the properties of accrual accounting, this must result in lower ROE in subsequent periods. Therefore, seen over a large number of companies and years, mean and median ROE could still be unbiased.

Table 6: Descriptive statistics of sample firms over three sub-periods

Model Inputs	1982-1990		1991-1999		2000-2008		1982-2008	
Variables:	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Price	39.694	34.000	37.214	31.250	36.328	30.590	37.466	31.750
Book value per share	25.538	18.244	16.857	10.793	19.835	10.203	20.103	11.730
Book-to-Market ratio	0.682	0.536	0.509	0.376	0.630	0.351	0.598	0.397
Dividend payout	0.324	0.319	0.239	0.188	0.149	0.000	0.224	0.170
ROE	0.106	0.139	0.125	0.134	0.145	0.129	0.128	0.134
FROE one-year-ahead	0.154	0.147	0.161	0.144	0.144	0.134	0.153	0.141
FROE two-years-ahead	0.163	0.156	0.171	0.154	0.163	0.141	0.166	0.149
LTG	0.133	0.120	0.152	0.140	0.162	0.150	0.152	0.140
Risk-free rate	0.092	0.083	0.063	0.063	0.045	0.045	0.063	0.061
Cost of equity (CAPM)	0.160	0.157	0.132	0.130	0.115	0.104	0.132	0.132
Cost of equity (FF)	0.157	0.156	0.139	0.138	0.139	0.135	0.143	0.141
No. of observations	2402		3701		3850		9953	

Note: The table shows mean and median firm-year values over three 9 year sub-periods. Price is on per share basis on the valuation date. Book value is calculated from common shareholder equity in the beginning of the year of valuation. Dividend payout is calculated as the annual dividends divided by reported earnings. ROE is the return on equity calculated as reported earnings divided by end-of-year book value. FROE one-year-ahead (two-years-ahead) is forecasted return on equity calculated as analyst's one-year-ahead (two-years-ahead) forecast of net income in the month of April of each year divided by forecasted end-of-year book value per share. Book value per share is forecasted trough the clean surplus relation, assuming constant dividend payout ratio. LTG is analysts' forecasts of the long-term growth rate in EPS. Risk-free rate is the 10 year US treasury yield. Cost of Equity (CAPM) is the cost of equity, calculated using CAPM (equation (18) with $\beta_{SMB} = \beta_{HML} = 0$). Cost of Equity (FF) is the cost of equity calculated using the FF three-factor model (equation (18)).

ward biased), forecasts of long-term growth are strongly upward biased which has also been noted by for example Frankel and Lee (1998) and Hermann et al. (2008).

The well known decline in treasury interest rates is seen in the table too which shows that for the first sub-period the average 10 year risk-free rate was 9.5% decreasing to 4.6% in the last sub-period. A similar pattern is seen for the CAPM based cost of equity which decreases from a mean (median) of 16 percent (15.7 percent) in the first sub-period to 11.5 percent (10.4 percent) in the last sub-period. Largely similar declines are seen from the first to the second sub-period for the cost of equity based on the FF 3 factor model. However, from the second to the third sub-period there is a small increase in the cost of equity.

In Table 7 I report the mean and median absolute valuation errors of the standard model for different assumptions about the calculation of the risk premium and different assumptions about the terminal growth rate.[26] When the 3 factor model is used in calculating the cost of equity, Table 8 shows similar results. The percentage valuation errors (PE) are calculated as $(P - V)/P$, and absolute percentage valuation errors (APE) are calculated as $|P - V|/P$, where P is the market value and V is the model value. It is seen from the tables that the one

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[26] As pointed out by Jorgensen et al. (2011), mean APE, 15% APE, and 25% APE can potentially yield a different ranking of models when the pricing error distribution has extreme values or skewedness. 25% APE is also called interquartile range and has been used in the literature by Liu et al. (2002) and Jorgensen et al. (2011).

factor approach is, in general, yielding lower errors than the three factor approach, so while the additional factors might have explanatory power as regards to returns on stocks, they seem to have less success explaining firm values, trough the cost of equity.

Considering PE, it is worth noting that all models price assets too low judged from the median. That is, even though analysts' forecasts of LTG are unreasonably high, this does not translate into too high valuations. So while LTG is unreasonably high, the estimates of the cost of equity must also be too high, and the error made in the cost of equity is dominating the error in forecasts of LTG. However, it should also be mentioned that many of the models perform relatively well as judged from mean PE. Furthermore, a median PE of 10 percent is still quite an impressive result.

In terms of mean APE the best performing assumption about terminal growth is the assumption of industry growth in the 3 factor case, while it is not so clear for the 1 factor case. It is also seen from mean APE that calculating the risk premia over either all data or 30 years of data yields the best results.

Median APE is a more important measure of performance since it is not affected to the same extend by outliers. Considering median APE the industry growth rate assumption performs the worst. The results are largely similar if assuming 0 percent and 3 percent growth rates. The two last columns in the tables show the percentage of companies for which the valuation error is larger than 15 and 25 percent, respectively. Also using these measures, the choice between 0 percent and 3 percent growth rate seems to make little difference. Both median APE, *15% APE,* and *25% APE* suggest that the risk premia should be calculated over long time series rather than short ones. For the investment strategy analysis in the next section I take the 1 factor based model with risk premium based on 30 years of data and terminal value with 3 percent growth rate as the best performing standard model.[27]

For comparison, the last row of both tables shows the results for the CCAPM valuation model. The implementation of the CCAPM model uses a very conservative estimate of zero growth from $3 - 12$ years ahead and -3 percent growth in the terminal value. While these assumptions might seem unreasonable at first glance, the valuation performance is remarkable. The model is performing on par with the best performing standard model when measured by mean and median PE.[28] However, when the more important APE measures are considered, the

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[27]Results in the next section are largely similar using the model with 0 percent growth and risk premia calculated using 30 years of data.

[28]The growth rate of -3 percent in the terminal value is deliberately chosen to make the model underprice to the same extend as the standard model to which it will be compared in the invenstment strategy analysis, i.e.,

Table 7: Performance meassure results for the standard model using CAPM based cost of equity compared to the CCAPM model

1 Factor	PE			APE				
	Mean	Median	S.D.	Mean	Median	S.D.	15% APE	25% APE
RIVCAll	0.289	0.404	0.504	0.495	0.462	0.334	0.877	0.783
RIVC5	-0.110	0.423	1.455	0.917	0.595	1.143	0.916	0.850
RIVC10	0.259	0.432	0.605	0.558	0.520	0.375	0.900	0.814
RIVC20	0.217	0.305	0.529	0.463	0.407	0.362	0.820	0.695
RIVC30	0.169	0.281	0.559	0.451	0.372	0.395	0.819	0.682
RIVGAll	0.068	0.288	0.785	0.557	0.432	0.573	0.850	0.734
RIVG5	-0.393	0.319	1.828	1.088	0.586	1.527	0.895	0.818
RIVG10	-0.020	0.329	1.029	0.701	0.511	0.766	0.879	0.790
RIVG20	-0.032	0.132	0.796	0.545	0.403	0.598	0.799	0.667
RIVG30	-0.126	0.104	0.883	0.561	0.359	0.707	0.776	0.628
RIVIAll	0.487	0.564	0.358	0.577	0.584	0.226	0.950	0.908
RIVI5	0.950	0.573	0.793	0.698	0.622	0.528	0.952	0.915
RIVI10	0.471	0.578	0.420	0.599	0.605	0.243	0.949	0.908
RIVI20	0.452	0.529	0.374	0.551	0.553	0.243	0.934	0.877
RIVI30	0.428	0.510	0.391	0.541	0.533	0.251	0.935	0.880
CCAPM	-0.022	0.114	0.639	0.400	0.283	0.513	0.718	0.551

Note: The table presents mean, median and standard deviation of the percentage valuation errors $(P - V)/P$, and of the absolute percentage valuation errors $|P - V|/P$. 15% APE (25% APE) shows the percentage of companies for which the valuation error is larger than 15 (25) percent. All valuations for the standard model (RIV) are based on the CAPM cost of equity. RIVC stands for constant RI, RIVG for growth in RI and RIVI for industry growth in the terminal value. The number in the model name in each row of column 1 indicates the number of years over which the factor risk premium is calculated and "All" stands for using all historical data, i.e., data since 1926. The last row shows results for the CCAPM model.

CCAPM model strongly outperforms any of the standard models. The median (mean) APE is 28.3 (40) percent compared to 35.9 (56.1) percent for the RIVG30 model and *15% (25%) APE* of 71.8 (55.1) percent compared to 77.6 (66.7) percent for the RIVG30 model.

Summary results for the CCAPM model are reported in Table 9. Again, I divide the results into the same 3 sub-periods, each of 9 years, and in the last column I report results for the full period. The most important results are in the first row which shows the APE. Naturally, the APE of the entire sample period is the same as the median APE from Table 7 and 8. It is seen that in particular in the first sub-period the model produces very low pricing errors of 23.8 percent increasing to 31.4 percent in the last sub-period. This result must be seen in light of the fact that I have been very easy on sampling assumptions, i.e., I have not sorted out outliers (unlike, for example Jorgensen et al. (2011)) or companies without a long time series of data (unlike, for example Nekrasov and Shroff (2009)) and still a 28.4 percent median APE is below any of their results for the standard model. This does not imply that the CCAPM model considered in this paper outperforms the factor model considered in Nekrasov and Shroff (2009), only that it outperforms any version of the standard model considered in the literature

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the RIVG30 model.

Table 8: Performance meassure results for the standard model using Fama-French 3 factor based cost of equity compared to the CCAPM mode

3 Factor	PE			APE				
	Mean	*Median*	*S.D.*	*Mean*	*Median*	*S.D.*	*15% APE*	*25% APE*
RIVCAll	0.256	0.464	0.767	0.608	0.542	0.551	0.903	0.825
RIVC5	-0.107	0.453	1.535	0.944	0.633	1.223	0.915	0.854
RIVC10	0.108	0.448	1.088	0.723	0.573	0.831	0.904	0.832
RIVC20	0.031	0.396	1.157	0.730	0.550	0.909	0.890	0.802
RIVC30	0.053	0.370	1.071	0.679	0.514	0.841	0.881	0.790
RIVGAll	0.027	0.370	1.109	0.705	0.525	0.867	0.881	0.797
RIVG5	-0.433	0.360	2.002	1.169	0.639	1.688	0.910	0.846
RIVG10	-0.202	0.350	1.569	0.914	0.576	1.298	0.890	0.819
RIVG20	-0.322	0.270	1.641	0.958	0.568	1.377	0.882	0.805
RIVG30	-0.285	0.239	1.518	0.880	0.522	1.276	0.869	0.776
RIVIAll	0.470	0.597	0.511	0.632	0.624	0.319	0.955	0.921
RIVI5	0.326	0.589	0.893	0.733	0.649	0.622	0.955	0.914
RIVI10	0.384	0.588	0.729	0.678	0.634	0.488	0.951	0.910
RIVI20	0.345	0.563	0.746	0.667	0.617	0.499	0.942	0.893
RIVI30	0.360	0.552	0.699	0.643	0.596	0.472	0.945	0.897
CCAPM	-0.022	0.114	0.639	0.400	0.283	0.513	0.718	0.551

Note: The table presents the mean, median and standard deviation of the percentage valuation errors $(P - V)/P$ and of the absolute percentage valuation errors $|P - V|/P$. *15% APE* (*25% APE*) shows the percentage of companies for which the valuation error is larger than 15 (25) percent. All valuations for the standard model (RIV) are based on the FF 3 factor cost of equity. RIVC stands for constant RI, RIVG for growth in RI, and RIVI for industry growth in the terminal value. The number in the model name in each row of column 1 indicates the number of years over which the factor risk premium is calculated and "All" stands for using data all historical data, i.e., data since 1926. The last row shows results for the CCAPM model.

when using median APE as the performance metric.

The second line of Table 9 reports the median PE and it shows that the model is under-valuing in all sub-periods. Even though APE is highest in the third sub-period, this error is not driven by the general undervaluation of the model since under-valuation is only 2.5 percent in this sub-period, well below roughly 15 percent for the first and second sub-period. From the table it is seen that risk adjustment is not the reason for this general undervaluation. In fact, the median absolute risk adjustment for period $1 - 12$ (RA 1-12) and absolute terminal risk adjustment (RA TV) are very conservative.[29] In the CCAPM literature it is a well known fact that aggregate consumption from the NIPA tables has too little variation to explain variation in asset returns. This could also be the driving factor behind the lack of risk adjustment in this model. However, if the risk adjustment of the model does not reflect how investors risk adjust stocks, this should result in large median APE, which is not the case.[30]

Recall, the CCAPM model ignores LTG and instead assumes a constant residual income in the period from $3 - 12$ years ahead and assumes -3 percent growth rate in the terminal

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[29]Naturally, this is a median value and therefore the values away from the median are much larger both to the positive and the negative side.

[30]Eliminating risk adjustment entirely from the CCAPM valuation is not a viable apporach since this increases both APE, 15% APE, and 25% APE.

Table 9: Summary results for the CCAPM valuation model

	1982-1990	1991-1999	2000-2008	1982-2008
	Median	Median	Median	Median
APE	0.2376	0.2931	0.3137	0.2835
PE	0.1474	0.1551	0.0251	0.1144
$\text{Re}\,BV^o$	-0.0185	0.0000	0.0000	-0.0000
μ	-0.0275	0.0518	0.0926	0.0424
ω_r	0.6072	0.5797	0.5422	0.5711
σ_{ra}	0.0001	0.0001	0.0001	0.0001
RA 1-12	0.0088	0.0135	0.0413	0.0169
RA TV	0.0045	0.0097	0.0239	0.0116
ReBV 1-5	0.2864	0.4521	0.5112	0.4274
ReBV 6-12	0.1715	0.3871	0.5230	0.3733
ReBV TV	0.1482	0.4777	0.8484	0.4856
No. of valuations	2403	3702	3851	9953

Note: The table shows median values of the performance and key elements of the valuation using the CCAPM model. APE are the absolute pricing errors, $|P-V|/P$. PE are the pricing errors, $(P-V)/P$. $\text{Re}\,BV^o$ is the estimated industry level of $\text{Re}\,BV$ at the time of the first observation in the $\text{Re}\,BV$ panel estimation. μ is the estimated industry growth in $\text{Re}\,BV$. σ_r is the estimated industry AR(1) coefficient. $\sigma_{ra} = cov(\varepsilon, \delta)$. RA 1-12 is the sum of discounted absolute risk adjustment from period 1-12. RA TV is the discounted terminal absolute risk adjustment. ReBV 1-5 is the sum of discounted ReBV in period 1-5. ReBV 6-12 is the sum of discounted ReBV for period 6-12. ReBV TV is the discounted terminal value ReBV. The final row shows the number of valuations in each period.

value. The results imply that investors are not willing to pay much for highly speculative future earnings, but instead takes on a very conservative view about value generation in the far future. Results also imply that the standard approach to risk adjustment is greatly overstating how much investors care about risk.

The third and fourth line of Table 9 show the median starting value for $\text{Re}\,BV$ and growth in $\text{Re}\,BV$ estimated from the industry panel estimations. One would in general expect that $\text{Re}\,BV^o$ is positive, but this is not confirmed. Results for the growth rate are somewhat more in line with what would be expected with slightly negative growth in the first sub-period, reflecting the bad state of the economy and reasonable positive values for the second and third sub-periods. A full period structural level growth of 4.2 percent is very much in line with what is expected.

One of the motivations behind using the residual income model in stead of for example the free cash flow or dividend discount models is that residual income is percieved to be a better measure of value creation. ROE is a key determinant of residual income, and Figure 1 shows several time series of ROE measures from 1972 (the first relevant year for valuation using the CCAPM valuation model) to 2008 for all companies in Compustat. It is seen that yearly average ROE follows the business cycle trough the past 40 years. ROE is low in the early eighties which is likely the reason why the median $\text{Re}\,BV^o$ and μ were estimated at low values for the first sub-period in Table 9. This is also the reason why the mean ROE is low

in the first sub-period, as shown in Table 6. The generally increasing pattern is nicely picked up by the estimates of the CCAPM model, as seen from the increasing parameter values of $\text{Re}\,BV^o$ and μ in Table 9. When subtracting the 10 year Treasury yield from ROE it is seen that even with this conservative meassure of cost of capital, companies were destroying value during the crisis in the early eighties and in the beginning of this century.

Figure 1: Time series of yearly average return on equity of companies in the Compustat database, as well as the average across all years 1972-2008. Companies are weighted according to their relative book value of equity.
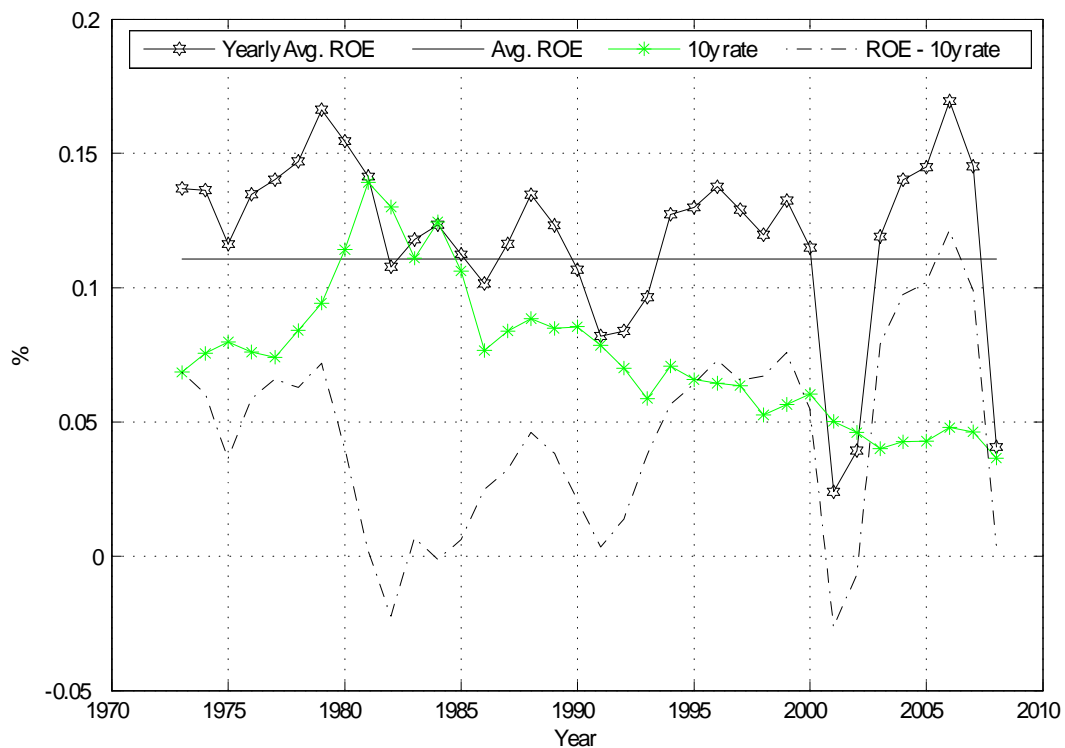
5.2 Investment Strategy Performance

In this section I take the best of the standard models, i.e., the 1 factor model with risk premium based on 30 years of data and 3 percent growth in terminal value, and compare it with the CCAPM valuation model. The comparison is carried out in an investment setup where I construct portfolios based on the model implied valuation errors and track their performance. This can be done in many different ways, and with many different performance metrics, but I will limit myself to a few simple methods and common performance measures. I will both create investment strategies based on all valuations trough the sample period and a recursive investment strategy based on the valuations performed once every year. Creating investment strategies based on all valuations for all years is closely related to the method of using mean and median measures for performance assessment. However, this is a back-testing approach, and since it uses all valuations performed trough the sampling period in the creation of investment strategies, one could not have traded on this strategy. Therefore I also consider a setup where, in each year, just after the valuation is performed (end of April), I construct portfolios based on the valuations performed only that year and track the performance of these portfolios. This strategy could have been implemented in practice each year trough the sampling period. Further, the strategies are simple buy and hold (for a year) strategies and therefore only influenced very little by trading costs. Trading costs have the same (negligible) influence on all portfolios and for each model and are therefore ignored.[31]

As mentioned by Shumway (1997) delisting returns are important to take into account. Stock returns and delisting returns are taken from CRSP. If a firm is delisted during the return period, the remaining return for the period is calculated by reinvesting in the value weighted market portfolio. This mitigates concerns about potential survivorship bias. I apply a delisting return of -100% for firms that are delisted for poor performance (CRSP delisting codes 500 and 520–584) if a delisting return is not available.

It is reasonable to say that a valuation model is good if it can predict which assets are expensive and which are cheap in the sense that if an investor invests in a cheap asset a high return will be realized and if an investor invests in an expensive asset a low return will be realized. According to the models, a stock is cheap if $(P-V)/P < 0$ and expensive if $(P-V)/P > 0$.

Table 10 shows $1-5$ year holding returns for 10 quantile portfolios,[32] average beta values for

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[31] Taxes can be ignored too since they influence the strategies similarly.

[32] As noted by Berk (2000), sorting could have important implications for the results. However, I see no reasons

the firms in each portfolio, and the number of stocks in each portfolio. The quantile portfolios are created by sorting all valuations performed in the sample period, and then creating a portfolio with each 10 percent quantile where the stocks with the 10 percent lowest values of $(P-V)/P$ (cheap stocks) are placed in the Q1 portfolio and those with the highest value of $(P-V)/P$ (expensive stocks) are placed in the Q10 portfolio. The 1 (or $2-5$) year return is calculated as the return earned if the investor invests equally in each stock, in the portfolio in the end of April of the valuation year, and holds the stock for 1 (or $2-5$) year. That is, the Q1 portfolio contains the cheapest stocks identified trough the sample period 1982-2008, and Q10 contains the most expensive stocks.

For both the standard model and the CCAPM model there is a clear pattern of higher returns for portfolios predicted to be cheap compared to portfolios predicted to be expensive. This pattern is seen for any of the holding return periods. It is also seen that the cheapest stock portfolio Q1 actually performs worse for the first year after the valuation compared to the stocks in the Q2 portfolio, in particular for the CCAPM model. However, looking at the 2 year and five year returns it is clear that the performance of this portfolio is picking up. This is in line with the notion that stocks will revert to their fundamental value sooner or later. If the market finds it very hard to realize the fundamental value of a stock, it might take more time to actually realize that value. Another explanation of the (possibly) unexpected returns of the Q1 portfolio is that this portfolio contains some outliers.

Both models are able to identify cheap and expensive stocks, and considering the average betas of the portfolios, it does not seem like higher risk drives the higher return. If one believes in the CAPM, beta is actually lower for cheap portfolios than for expensive portfolios for both the standard and CCAPM model. The same pattern is seen for the market factor if one believes in the 3 factor model. The SMB factor is larger for both cheap and expensive portfolios compared to intermediate portfolios. The HML factor, on the other hand, is substantially larger for the cheap portfolios than for the expensive portfolios, indicating that some of the higher return can be explained by this factor.

The returns shown in Table 10 are nominal returns. These give a clear indication that the cheap portfolios earn higher returns than expensive portfolios. Figures 2 and 3 show how the portfolio returns evolve in excess of the return on the value weighted market portfolio. From these figures it is clear that for both models the cheap portfolios outperform the expen-

why it would favor one model over another in this analysis.

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Table 10: Summary return results for quantile portfolios based on the standard and CCAPM valuation model

Standard model	1y	2y	3y	4y	5y	β_{mkt}	β_{mkt}^{FF}	β_{SMB}^{FF}	β_{HML}^{FF}	Obs.
Q1 (Cheap)	0.149	0.297	0.563	0.781	0.944	0.779	0.918	0.523	0.438	995
Q2	0.159	0.309	0.531	0.695	0.917	0.798	0.932	0.394	0.383	996
Q3	0.161	0.321	0.519	0.709	0.917	0.912	0.976	0.412	0.252	995
Q4	0.160	0.302	0.485	0.713	0.931	0.968	1.007	0.349	0.164	995
Q5	0.150	0.322	0.523	0.686	0.889	1.058	1.055	0.358	0.067	996
Q6	0.141	0.271	0.465	0.686	0.918	1.118	1.088	0.356	-0.014	996
Q7	0.129	0.271	0.411	0.582	0.766	1.174	1.124	0.384	-0.039	995
Q8	0.104	0.188	0.397	0.517	0.703	1.288	1.216	0.440	-0.067	995
Q9	0.092	0.188	0.246	0.347	0.455	1.480	1.334	0.533	-0.179	996
Q10 (Expensive)	0.075	0.131	0.200	0.295	0.459	1.993	1.684	0.719	-0.560	995
CCAPM model	1y	2y	3y	4y	5y	β_{mkt}	β_{mkt}^{FF}	β_{SMB}^{FF}	β_{HML}^{FF}	Obs.
Q1 (Cheap)	0.123	0.268	0.544	0.749	0.929	1.225	1.282	0.584	0.338	995
Q2	0.170	0.273	0.505	0.666	0.889	1.080	1.156	0.561	0.344	996
Q3	0.162	0.314	0.538	0.787	0.965	1.052	1.117	0.408	0.277	995
Q4	0.133	0.277	0.425	0.633	0.903	1.097	1.121	0.426	0.169	996
Q5	0.124	0.283	0.446	0.621	0.819	1.104	1.107	0.383	0.088	996
Q6	0.138	0.272	0.421	0.617	0.792	1.073	1.072	0.386	0.090	995
Q7	0.168	0.312	0.508	0.680	0.904	1.145	1.095	0.345	-0.059	995
Q8	0.150	0.284	0.483	0.635	0.809	1.163	1.068	0.403	-0.175	995
Q9	0.110	0.192	0.320	0.447	0.619	1.260	1.142	0.418	-0.239	996
Q10 (Expensive)	0.041	0.124	0.181	0.259	0.402	1.373	1.178	0.549	-0.393	995

Note: Based on a ranking of $(P-V)/P$ in each model, 10 quantile portfolios are created where Q1 is the portfolio containing the companies with the lowest value of $(P-V)/P$ and Q10 contains the companies with the highest $(P-V)/P$. Each portfolio contains 10 percent of the companies in the entire sample. The table shows $1-5$ year nominal holding returns including distributions. The columns with $\beta-$values show the average beta for the companies in the portfolio. The last column shows the number of observations in each portfolio.

sive portfolios and the cheap portfolios greatly outperform both the value weighted and equal weighted market returns. It is further seen that the equal weighted market return (dashed line) outperforms the value-weighted return, supporting the empirical studies finding that, in general, returns on small companies are larger than returns on large companies (i.e., the SMB factor is relevant for explaining returns). Based on these figures both valuation models identify over- and under-valued stocks and seem to do so equally well.

Figure 2: 1-5 year portfolio returns in excess of the value weighted market return for the standard valuation model
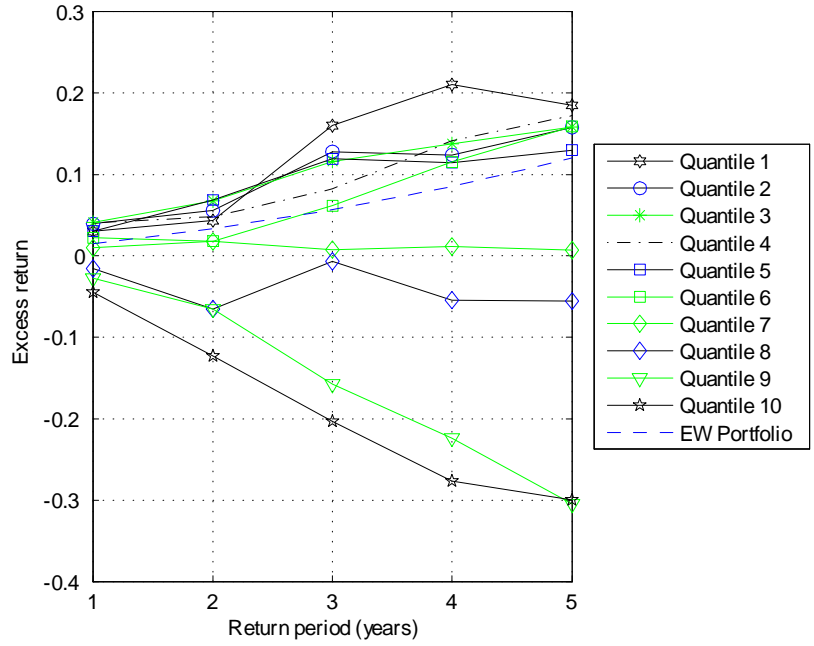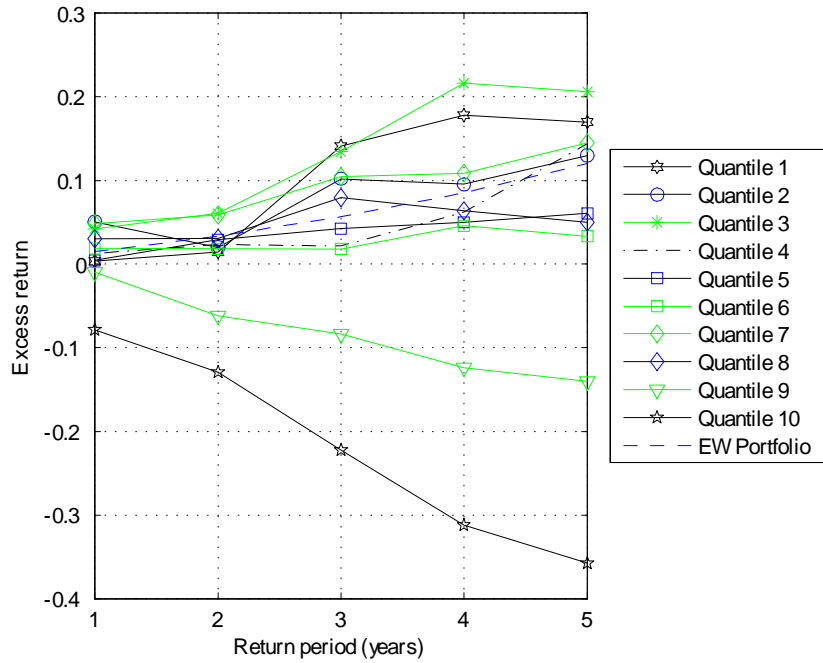
Figure 3: 1-5 year portfolio returns in excess of the value weighted market return for the CCAPM valuation model

The above results apply to a strategy that an investor could not implement in practice since it creates the quantile portfolios based on all valuations trough the sample period. In all the following figures I focus on strategies that could have been implemented in practice. The valuations are made mid April each year, and based on these valuations, I construct quantile portfolios using the usual ranking from cheap to expensive companies. This strategy is easily implementable in practice since it only requires buying and selling stocks once a year. Since longer term returns might be biased (due to potential bias in delisting returns), I focus mainly on one year returns in the following.

In Figure 4 I compare 1 year excess returns over the value weighted market return for the quantile portfolios based on both the standard and the CCAPM model. As portfolios become more expensive the pattern of decreasing returns is very strong. In particular for the CCAPM model, with a difference in annual returns between the Q2 and Q10 portfolios of roughly 9 percent. It is clear that ranking companies each year only, using data available in that year, still supports the notion that both the standard and the CCAPM valuation model identify over- and under-valued companies when considering 1 year returns. However, the pattern seems slightly more convincing for the CCAPM model.

Figure 4: 1 year portfolio returns in excess of the value weighted market return for both the standard model and the CCAPM model
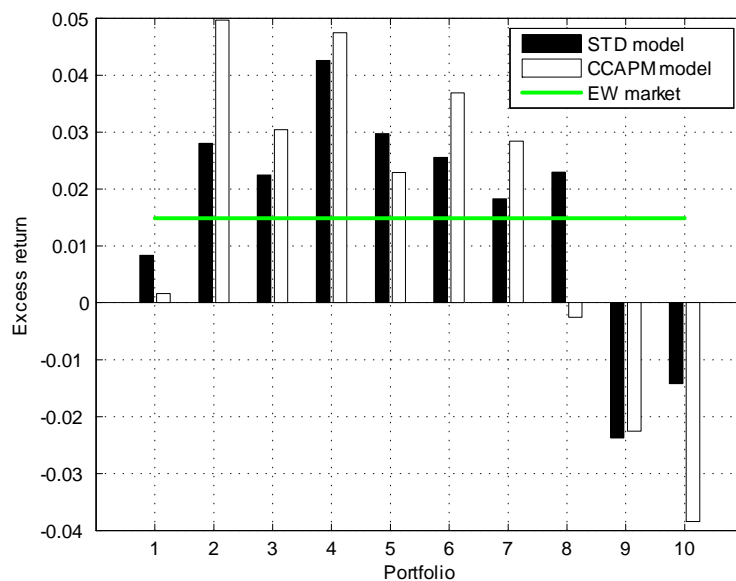
While Figure 4 implies that both models are able to identify cheap and expensive stocks, judged in terms of raw returns, it does not take the risk of these returns into account. As was implied from the beta risk measures in Table 10, there seems to be a significant differences between risk in the portfolios across the two models. Therefore, I compare risk adjusted returns in the next figures. There are several ways of adjusting for risk, but the most common method in the literature is to consider beta risk, either using only the market factor or additionally using the SMB and HML factors too, i.e., the 3 FF factors. I follow the method described in Landsman et al. (2011). Firm i's expected equity return for year $t+1$ as of year t, ER_{t+1}^i is calculated as[33]

$$ER_{t+1}^i = r_{1y,t+1}^f + \beta_{MKT,t+1}^i RP_{t+1}^M + \beta_{SMB,t+1}^i RP_{t+1}^{SMB} + \beta_{HML,t+1}^i RP_{t+1}^{HML},$$

in the 3 factor case and with $\beta_{SMB,t+1}^i = \beta_{HML,t+1}^i = 0$ and $\beta_{MKT,t+1}^i$ replaced by the market beta from a standard CAPM regression in the 1 factor case. The betas (factor loadings) for each company for each year and risk premia for each portfolio for each year were already calculated in the implementation of the standard model and can be re-used here. The risk adjusted returns for each company is then calculated as $R_{t+1}^i - ER_{t+1}^i$. Knowing which portfolio an asset belongs to and its risk adjusted return, it is straight forward to calculate the portfolio excess returns.[34]

When using CAPM based risk adjustment the results in Figure 5 are obtained. The pattern of decreasing returns as portfolios become more expensive is sustained, and for the standard model the pattern is even stronger compared to that in Figure 4. Both models indicate an annual difference between returns of Q2 and Q10 portfolios of around $8 - 9$ percent. For both models the Q1 portfolio is still falling outside the usual pattern. So risk adjusting the returns with the CAPM factor does not seem to capture the abnormal returns of this portfolio from either model.

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[33]In this notation a year goes from the end of April in year t to the end of april April in year $t+1$.

[34]In this implementation of risk adjusted returns, the risk adjustment is based entirely on data prior to the investment date. Alternatively one could calculate the risk adjustment based on returns trough the holding period which would yield information about risk of the position in the actual holding period. Indeed most investors care about the risk of a position during the period in which they hold the position rather than during an arbitrary past period in which they did not hold the position. However, I do not take the latter approach since this is not standard in the litterature.

Figure 5: 1 year portfolio returns in excess of CAPM based expected return for both the standard model and the CCAPM model
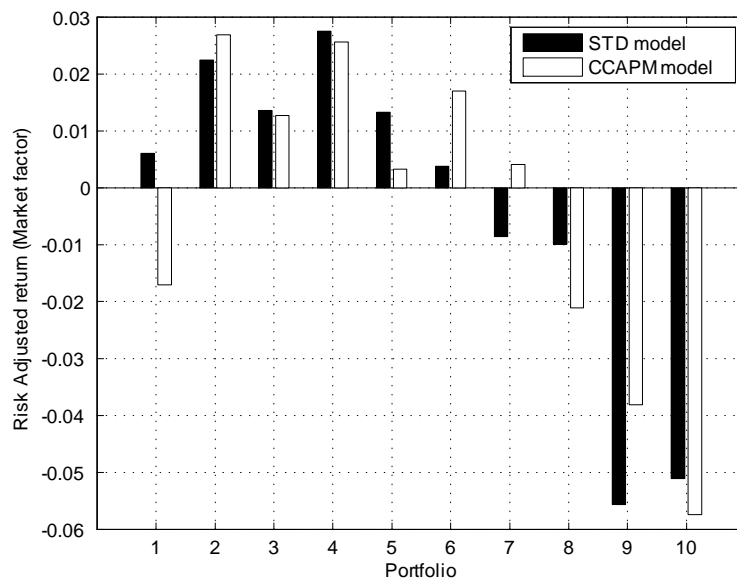
Risk adjusting, using the FF 3 factor approach changes the picture substantially for both models. Results are shown in Figure 6. For both models a substantial part of the excess returns seems to disappear when the risk adjusted returns are calculated using the FF 3 factor model. For both models the Q2 portfolio still outperforms the portfolios with expensive stocks, but to a less extend compared to the previous figures. This suggests that the high returns of cheap stock portfolios identified by both models is nothing but a compensation for taking on excessive risk, while the low returns of expensive stocks portfolios produce low returns because they contain less risk in terms of the 3 FF factors.[35]

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[35] As will be shown in the robustness analysis, the CCAPM model is able to identify cheap and expensive stocks even in the FF 3 factor sense when analysts' estimates of LTG are utilised.

Figure 6: 1 year portfolio returns in excess of Fama-French 3 factor based expected return for both the standard model and the CCAPM valuation model
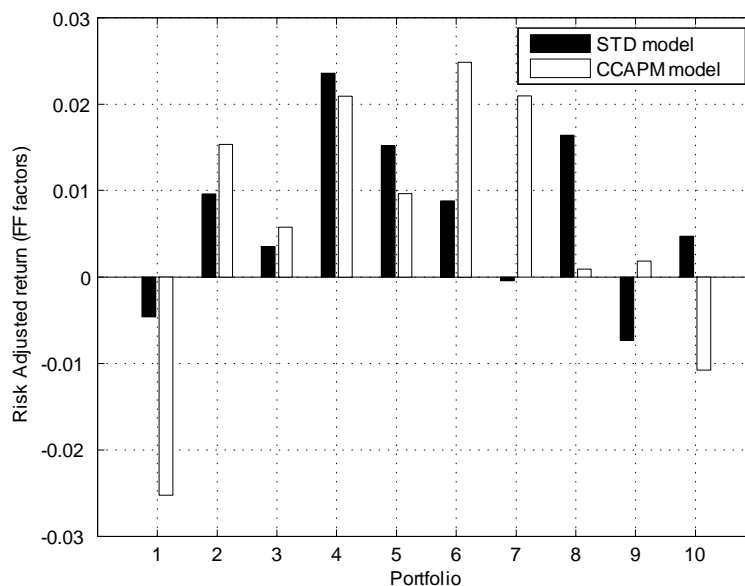
From the above results an obvious strategy would seem to go long in the Q2 portfolio and short in the Q10 portfolio. The time series of the difference between the returns of these portfolios is shown in Figure 7 for the portfolios based on the standard model and in Figure 8 for portfolios based on the CCAPM model. For both models the return is positive in most periods, and for the portfolios based on the CCAPM model this is much more consistently so than for those based on the standard valuation model. In particular, in the recent periods the strategy based on the CCAPM model seems to outperform the strategy based on the standard model. In the figures the differences between raw returns, the differences between CAPM risk adjusted returns, and the differences between FF 3 factor risk adjusted returns are shown. Interestingly, the conclusions are largely similar across measures. However, using the FF risk adjustment seems to greatly favor the strategy based on the CCAPM model in the years 2003 and 2005, since the difference in returns between Q2 and Q10 portfolios are respectively around −40 percent and −80 percent for the standard model, whereas for the CCAPM model they are around 0 percent and −20 percent. It is worth noting that the strategies do not seem to be negatively affected by economic crises. In particular for the crisis around 2001 the strategy produces some of the highest returns, independently of the valuation model. Also considering

the recent crisis which would be present in the returns for the investment made in 2008, the performance of the strategy seems relatively unaffected with returns around zero.

Figure 7: Time series of differences between Q2 and Q10 portfolios based on the standard model
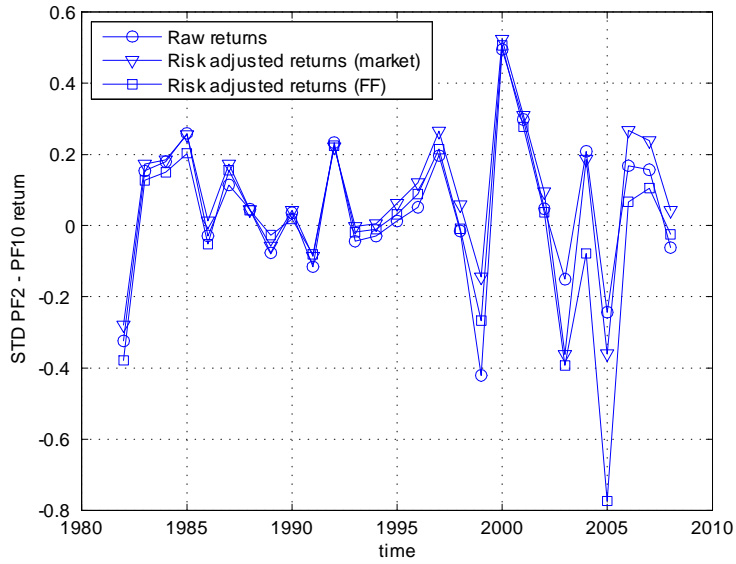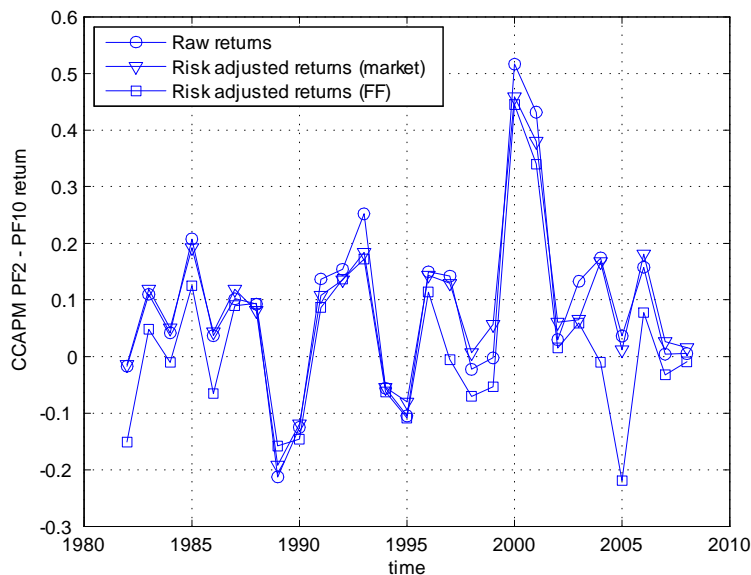
Figure 8: Time series of differences between Q2 and Q10 portfolios based on the CCAPM model


In the above analysis risk adjustment has centered around adjusting returns for factor risk. While this is a standard approach in the academic literature, it is not the standard approach taken by investment banks and hedge funds. These institutions seem to care much more about the variation of returns over time since this has a more direct and potentially devastating effect on their accounts. As a result the Sharpe ratio introduced in Sharpe (1965) is a widely used measure of risk adjusted excess return. In the previous analysis only little information on this measure has been identified. For example the returns based on going long in Q2 and shorting Q10, shown in Figures 7 and 8 give no clear indication of which return series is the most volatile.

In Figure 9 I plot Sharpe ratios for each quantile portfolio for each of the models. The Sharpe ratios are calculated over the 27 1 year returns resulting from buying each portfolio in the end of April and holding it until the end of April the following year. To avoid a discussion over which risk-free interest rate to use in the calculation, I calculate the Sharpe ratio as the return on the portfolio divided by the volatility of the portfolio, and thus I do not adjust for any risk-free rate. Again, it is seen that based on this performance measure the Q1 portfolio performs poorly compared to the Q2 portfolio and the Q9 and Q10 portfolios are the worst performing portfolios. In general, the downward slope of performance seems to be preserved

using this measure in the sense that cheap portfolios are preferred over expensive portfolios. Again, the models perform relatively equal, and portfolios Q2-Q6 seem to perform equally well according to this measure. That is, while the cheap portfolios have higher returns than the mid portfolios, they also have a higher volatility.

Figure 9: Sharpe ratios for 1 year returns for each of the quantile portfolios for both the standard and the CCAPM model
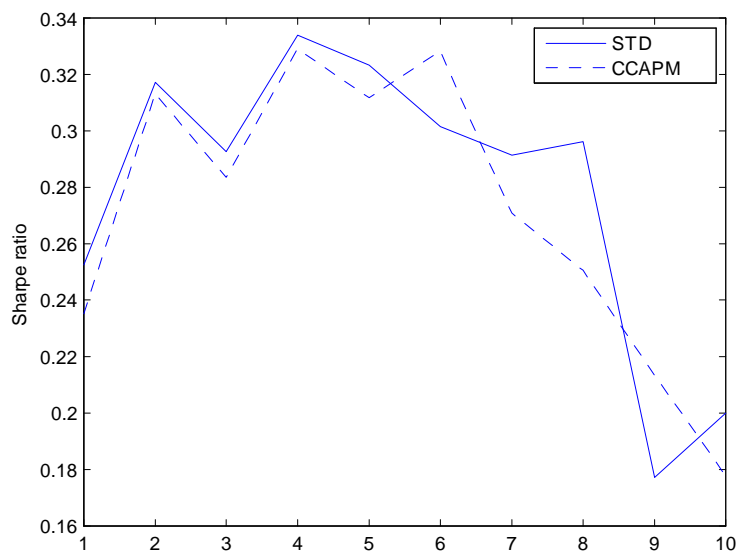

While investors care about return volatility, it is also natural that they care more about downside risk than upside risk. The Sharpe ratio does not distinguish between upside and downside risk which is a common criticism of the Sharpe ratio as a performance measure. An alternative measure that has gained much popularity recently (see, e.g., Pedersen and Satchell (2002), Estrada (2006) and Dias (2011)) is the Sortino ratio introduced in Sortino et al. (1994). In it's nature it is similar to the Sharpe ratio in the sense that it adjusts returns for volatility. However, while the Sharpe ratio penalizes returns equally for upside risk and downside risk, the Sortino ratio only penalizes downside risk. I calculate the Sortino ratios for each portfolio using the formula

$$Sortino\ ratio = \frac{\bar{R} - T}{\sqrt{\frac{\sum I_{R_t < T}(R_t - T)}{N}}},$$

where $\bar{R}$ is the mean return T is a threshold and N is the number of annual returns for

which $R_t < T$.[36]   Here I choose $T = 0$, i.e., I only penalize if the returns are negative.[37] Figure 10 shows the Sortino ratios for each portfolio and for both the standard and CCAPM model. Interestingly, the CCAPM model, again, shows the desired decreasing pattern across portfolios, while the standard model does not quite replicate the desired structure. This implies that the cheap portfolios based on the standard model have substantial downside risk, while the cheap portfolios based on the CCAPM model have upside risk. This pattern is may not be too surprising since Figure 7 indicated that Q2 based on the standard valuation model had substantial worse performance than Q10 for some years. This, together with the fact that the Q2 portfolio, on average, performs substantially better than the Q10 portfolio, suggests that there must be many periods where the Q10 portfolio is performing very poorly.

Figure 10: Sortino ratios for 1 year returns for each of the quantile portfolios and for both the standard and the CCAPM model
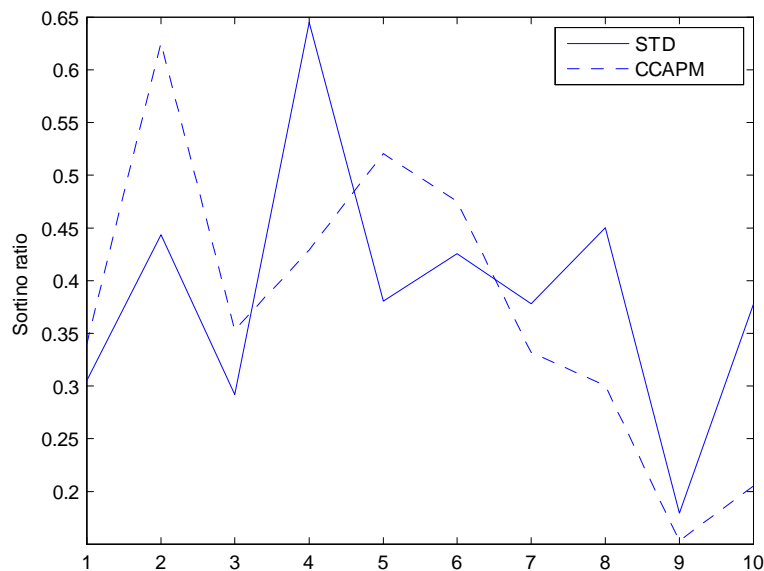
Figures 11 and 12 show Sortino ratios for each portfolio for up to 5 years holding periods, based on the standard model and the CCAPM model respectively.[38] The curves from Figure 10

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[36]The term in the denumerator is a specific meassure of downside risk introduced in Sortino and der Meer (1991), also called semideviation.

[37]Naturally, the choice of T has much impact on the level of the Sortino ratios, but here conclusions are the same for any reasonable choice of T.

[38]As mentioned earlier, there is a potential delisting return bias in these returns.

are replicated in the figures for the 1 year holding period results. Interestingly, for the CCAPM model the downward sloping pattern across portfolios is not as strong for longer holding period returns as for the 1 year returns. The returns of portfolios based on the standard valuation model, on the other hand, do not have a downward sloping pattern for the 1 year return, but have a more smooth downward sloping pattern for longer holding periods. Another interesting point to deduce from these figures is that the return on the cheapest portfolio (Q1) is picking up as time passes. This pattern was already seen in Table 10 and Figures 2 and 3.[39] This confirms that it takes more time for the market to realize the value of the most under-valued companies.

Figure 11: Sortino ratios for 1-5 year returns for each of the quantile portfolios and for the standard model

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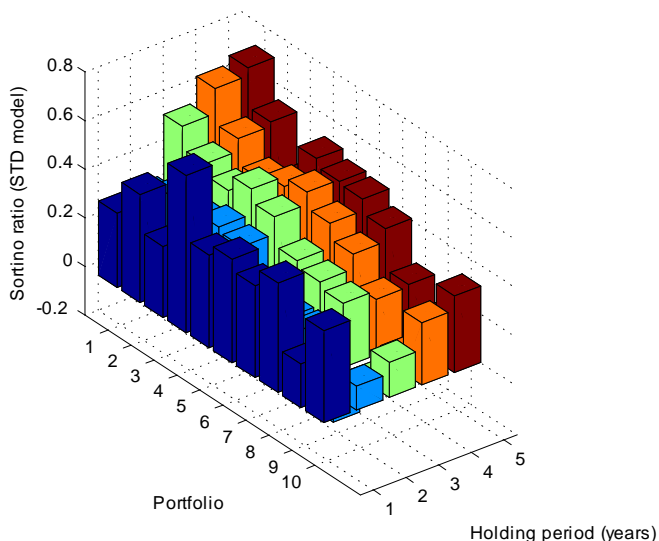
[39]Recall, those results were based on quantile portfolios using all valuations performed trough the valuation period.

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Figure 12: Sortino ratios for 1-5 year returns for each of the quantile portfolios and for the CCAPM model
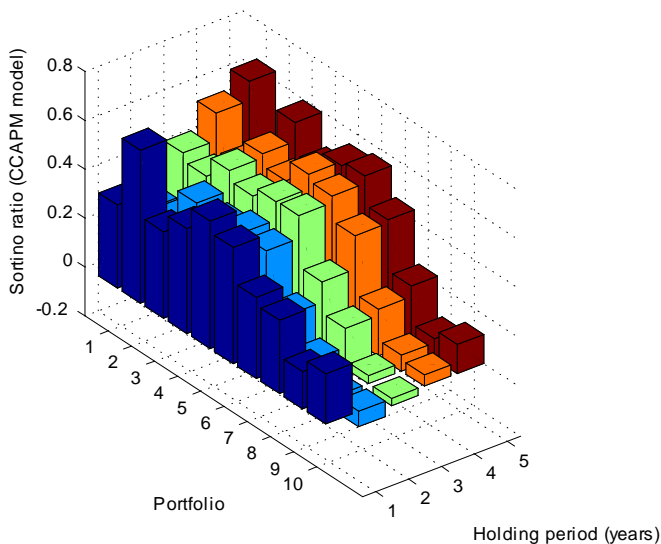
6 Further Robustness Checks

6.1 Including Financial and Utilities Companies

In the previous section financial and utility companies were excluded. The literature is mixed on the treatment of these companies, and as a robustness check I also perform the analysis, including these companies. Table 11 shows simple descriptive statistics of beta-values in the increased sample, and interestingly the mean and median betas are very different in this sample compared to the sample excluding financial and utility companies. Mean and median values of the market factor in the CAPM model are roughly 0.1 lower, and they are roughly 0.05 lower in the FF model. Betas on the SMB portfolio are about 0.1 lower, while they are about 0.2 higher on the HML factor. Notice, the sample still includes all companies analyzed in Section 5, and therefore the results suggest that financial and utility companies have much different betas than the rest of the sample. In particular they have a lower market beta. This opens up for the potential for very different performance of the valuation models in this sample. The analysts' estimates of LTG are substantially lower in the sample including financial and utility companies, with a median of 12 percent for the full period from 1982-2008, compared to 14

Table 11: Descriptive statistics of betas

Descriptive statistic	1 Factor	FF mkt	FF smb	FF hml
Mean	1.034	1.077	0.321	0.208
Median	0.958	1.018	0.226	0.320
Standard deviation	0.663	0.579	0.748	0.928
Skewness	1.469	0.936	0.923	-1.029
Kurtosis	8.008	6.307	5.252	6.833

Note: The table reports descriptive statistics of the calculated beta-values. The second column reports descriptive statistics when using the market portfolio as the only factor. The columns 3-5 report descriptive statistics when using the three FF portfolios as risk factors. Compared to Table 5 this table includes financial and utility companies.

percent when financial and utility companies are excluded. Again, this could potentially change valuation performance of the standard model substantially.

Including financial and utility companies increases the sample to $14,689$ valuations on $2,479$ companies. In general, the 1 factor standard model still performs better than the FF 3 factor model (in terms of APE), and therefore I only show valuation error results in Table 12 for the 1 factor models. Again, the last row shows the results for the CCAPM model. The best performing standard model (judged on median APE) is the no growth model with risk premium calculated based on 30 years of data. However, this model still has slight undervaluation (seen from PE), whereas the similar model with growth has no general undervaluation. Again, all standard models are outperformed by the CCAPM model which both produces lower APE and PE very close to 0. Also judged from the number of companies with valuation errors above 15 and 25 percent, the CCAPM model outperforms all versions of the standard model.

Figure 13 shows some of the key figures from the analysis of returns on quantile portfolios. The top left plot illustrates that returns, adjusted for the market factor, show a very clear decreasing pattern across portfolios for both models. This is similar to the analysis without financial and utility companies. Also similar to the previous analysis, the 3 FF factors seem to explain much of the difference in returns, which is seen from the top right plot. From the bottom left plot it is clear that both models are able to identify over- and undervalued portfolios as judged from the Sharpe ratio of one year returns. As seen from the bottom right plot, in particular, the CCAPM model is also able to identify over- and undervalued portfolios, as judged by the Sortino ratio. Only portfolios 1 and 6 deviate from a perfectly smooth decreasing Sortino ratio across portfolios for the CCAPM model.

As in the previous analysis a similar decreasing pattern of Sharpe and Sortino ratios across portfolios is obtained on portfolios held over longer horizons (at least up to 5 years). Furthermore, portfolio 1 retains its clear tendency to pick up and actually become the best performing

Table 12: Standard model mean and median absolute percentage deviations from market values

1 Factor	PE			APE				
	Mean	Median	S.D.	Mean	Median	S.D.	15% APE	25% APE
RIVCAll	0.187	0.303	0.509	0.451	0.410	0.331	0.819	0.703
RIVC5	-0.154	0.318	1.345	0.841	0.543	1.070	0.868	0.781
RIVC10	0.170	0.328	0.594	0.513	0.472	0.370	0.846	0.745
RIVC20	0.111	0.203	0.539	0.443	0.377	0.353	0.792	0.659
RIVC30	0.069	0.174	0.539	0.421	0.336	0.370	0.774	0.625
RIVGAll	-0.103	0.151	0.877	0.594	0.416	0.668	0.834	0.708
RIVG5	-0.498	0.179	1.766	1.077	0.559	1.491	0.877	0.791
RIVG10	-0.164	0.187	1.064	0.718	0.489	0.813	0.857	0.755
RIVG20	-0.212	-0.010	0.888	0.621	0.439	0.683	0.822	0.702
RIVG30	-0.301	-0.052	0.942	0.633	0.396	0.772	0.800	0.663
RIVIAll	0.433	0.515	0.349	0.527	0.539	0.224	0.924	0.863
RIVI5	0.276	0.525	0.822	0.676	0.590	0.560	0.937	0.886
RIVI10	0.424	0.530	0.402	0.551	0.564	0.238	0.929	0.869
RIVI20	0.394	0.478	0.374	0.506	0.512	0.242	0.903	0.826
RIVI30	0.371	0.458	0.377	0.491	0.490	0.241	0.901	0.823
CCAPM	-0.089	-0.004	0.532	0.374	0.276	0.406	0.707	0.540

Note: The table presents the mean, median and standard deviation of the percentage valuation errors $(P-V)/P$ and of the absolute percentage valuation errors $|P-V|/P$. *15% APE* (*25% APE*) shows the percentage of companies for which the valuation error is larger than 15 (25) percent. All valuations for the standard model (RIV) are based on the CAPM cost of equity. RIVC stands for constant RI, RIVG for growth in RI and RIVI for industry growth. The number in the model name in each row of column 1 indicates the number of years over which the factor risk premium is calculated, and "All" stands for using all historical data, i.e., data since 1926. The last row shows results for the CCAPM model. Unlike Table 7 this table includes financial and utility companies.

portfolio on a 5 year horizon. All in all, while financial and utility companies are quite different from other companies in terms of factor betas and analysts' forecasts of LTG, including these companies in the analysis does not change any of the conclusions of the analysis in Section 5, and the CCAPM model still outperforms the standard models.

Figure 13: Various performance meassures to compare performance of portfolios based on the standard and CCAPM model when financial and utilities companies are included in the sample
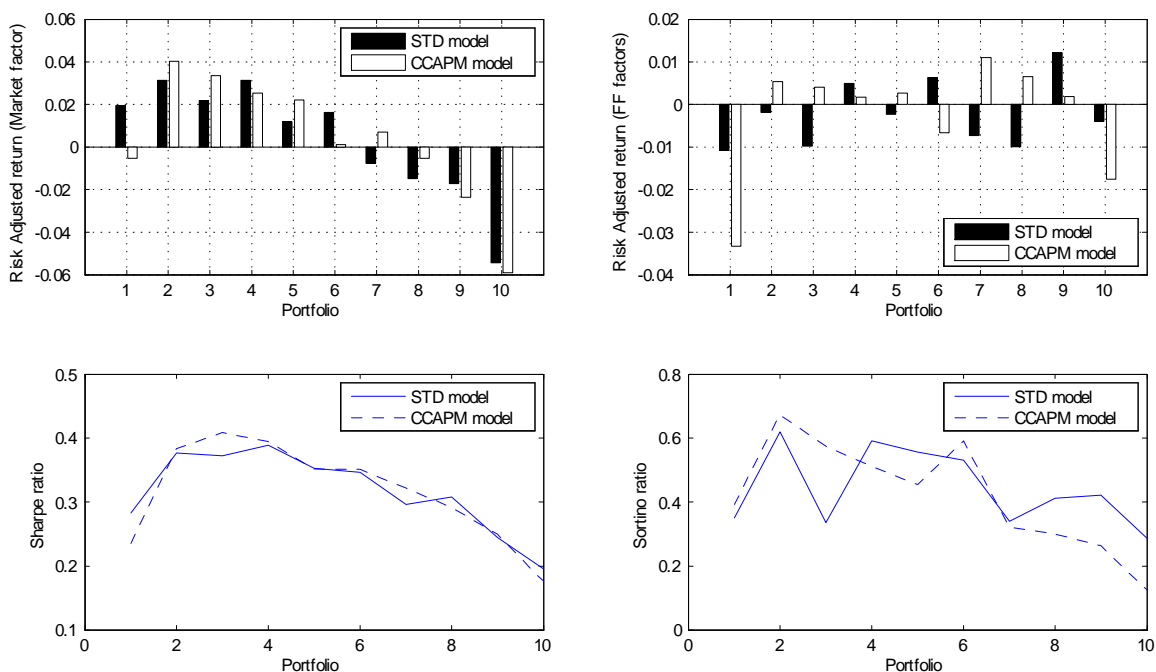
6.2 Using Forecasts of LTG in the CCAPM Valuation Model

It is clear that the very high LTG forecasts are crucial for the standard valuation model. Even with these high forecasts the standard model still generally values companies too low compared to the market value. While the LTG forecasts are needed for the standard model to get nearly high enough estimates of firm value, compared to the market value, it is not clear if they also introduce noise in the model, which introduces a partial negative effect to the valuation performance. Therefore, in this section I use the LTG forecasts in the CCAPM model. Naturally, without any further changes to the model, it will overvalue companies, compared to market values, due to LTG forecasts being too high. To counter this, I use an even more conservative growth rate of -5 percent in the terminal value. Besides this, no further changes are made to the analysis compared to the one in Section 5, i.e., I do not include financial and

Table 13: Summary results for the CCAPM valuation model

Variables:	1982-1990 Median	1991-1999 Median	2000-2008 Median	1982-2008 Median
APE	0.2140	0.2799	0.3795	0.2955
PE	-0.1087	-0.1269	-0.2790	-0.1707
Re BV^o	-0.0185	0.0000	0.0000	-0.0000
μ	-0.0275	0.0518	0.0926	0.0424
ω_r	0.6072	0.5797	0.5422	0.5711
σ_{ra}	0.0001	0.0001	0.0001	0.0001
RA 1-12	0.0088	0.0135	0.0413	0.0169
RA TV	0.0045	0.0097	0.0239	0.0116
ReBV 1-5	0.3935	0.5861	0.6679	0.5663
ReBV 6-12	0.4352	0.7590	0.9674	0.7386
ReBV TV	0.3150	0.7585	1.2132	0.7622
No. of valuations	2403	3702	3851	9953

Note: The table shows median values of the performance and key elements of the valuation, using the CCAPM model. APE are the absolute pricing errors, $|P-V|/P$. PE are the pricing errors, $(P-V)/P$. Re BV^o is the estimated industry level of Re BV at the time of the first observation in the Re BV panel estimation. μ is the estimated industry growth in Re BV. σ_r is the estimated industry AR(1) coefficient. $\sigma_{ra} = cov(\varepsilon, \delta)$. RA 1-12 is the sum of discounted absolute risk adjustment from period 1-12. RA TV is the discounted terminal absolute risk adjustment. ReBV 1-5 is the sum of discounted ReBV in period 1-5. ReBV 6-12 is sum of discounted ReBV for period 6-12. ReBV TV is the discounted terminal value ReBV. The final row shows the number of valuations in each period. Compared to Table 9 the results in this table are calculated using analysts' forecasts of LTG and assuming -5 percent growth in the terminal value.

utility companies.[40]

The results for the CCAPM model are summarized in Table 13. The estimated values and the risk adjustment are unchanged since these are from a regression using the same historical data as in Section 5. Due to the large and positive estimates of LTG, the values of ReBV 1-5 and ReBV 6-12 are much higher than for the results in Section 5, and even though the terminal growth has been decreased, from -3 percent to -5 percent, the terminal value is also increased (can be seen from ReBV TV). Because of this the model now substantially overvalues stocks. Even so the median APE is still substantially lower (29.6 percent) than the best performing standard model (35.9 percent). Further, for the CCAPM model 71.7% of the valuations are done with an error higher than 15%, comparable to 77.6% for the best standard model.[41]

Figure 14 shows some of the key figures from the analysis of returns on quantile portfolios. Again, when adjusting returns by the market factor, both models identify over- and under-valued companies relatively well, with portfolios 2-4 strongly outperforming portfolio 9-10. Surprisingly, for the CCAPM model this picture is largely maintained, even when adjusting returns by the 3 FF factors, as seen from the top right figure. This suggests that the LTG forecasts contain important information about future performance of stocks, and that this is utilized much better in the CCAPM model compared to the standard model. Since the only

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[40]Conclusions are unchanged if these companies are included.

[41]Comparable results for the standard model are from Table 7.

difference between models is the discount factor, one natural explanation is that the information in the LTG forecasts gets "polluted" by the noisy discount factor in the standard model. From the bottom plots it is seen that the models seem to have equal performance as judged by the Sharpe ratio, but when considering the Sortino ratio the downward sloping pattern is again more clear for the CCAPM model. This suggests that it is important to distinguish between upside and downside risk in comparing returns from portfolios based on the different models.

Figure 14: Various performance meassures to compare performance of portfolios based on the standard and CCAPM model when analysts' forecasts of long term growth are utilized in the CCAPM model together with an assumption of -5 percent growth in the terminal value
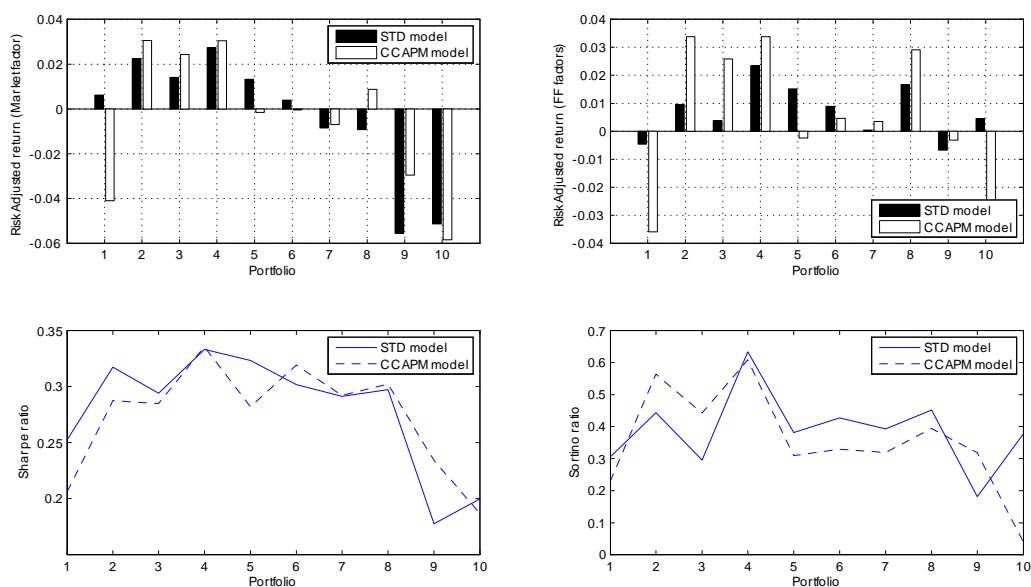

It is clear from the above analysis that -5 percent growth in the terminal value is not sufficient to get unbiased valuation using the CCAPM model. Yet, even though value estimates were more biased in the CCAPM model compared to the standard model, the performance in terms of all considered performance measures was either at least comparable (Sharpe ratio and Market adjusted returns) or better (APE, 15% APE, 25% APE, Sortino ratio and FF adjusted returns) than the best performing standard model. Since the CCAPM model performs very well

in terms of FF risk adjusted returns on quantile portfolios, it becomes interesting to analyze the performance on an unbiased version of the CCAPM model using LTG. If I still only adjust the terminal growth rate, it requires a negative growth of $15 - 20$ percent in the terminal value. Using the extremely conservative estimate of -20 percent growth in the terminal value, the model only produces APE of 24.9 percent and 15% APE of 67.6 percent compared to 35.9 percent and 77.6 percent respectively for the best standard model.

The plots in Figure 15, where the CCAPM model is based on a negative growth rate of 20 percent in the terminal value, are very similar to those in Figure 14 which were based on a negative growth rate of 5 percent. Thus, the more precise valuation using -20 percent growth instead of -5 percent growth does not significantly change the ranking of companies within a year, and therefore it does not significantly change returns based on quantile portfolios.

Figure 15: Various performance meassures to compare performance of portfolios based on the standard and CCAPM model when analysts' forecasts of long term growth are utilized in the CCAPM model together with an assumption of -20 percent growth in the terminal value
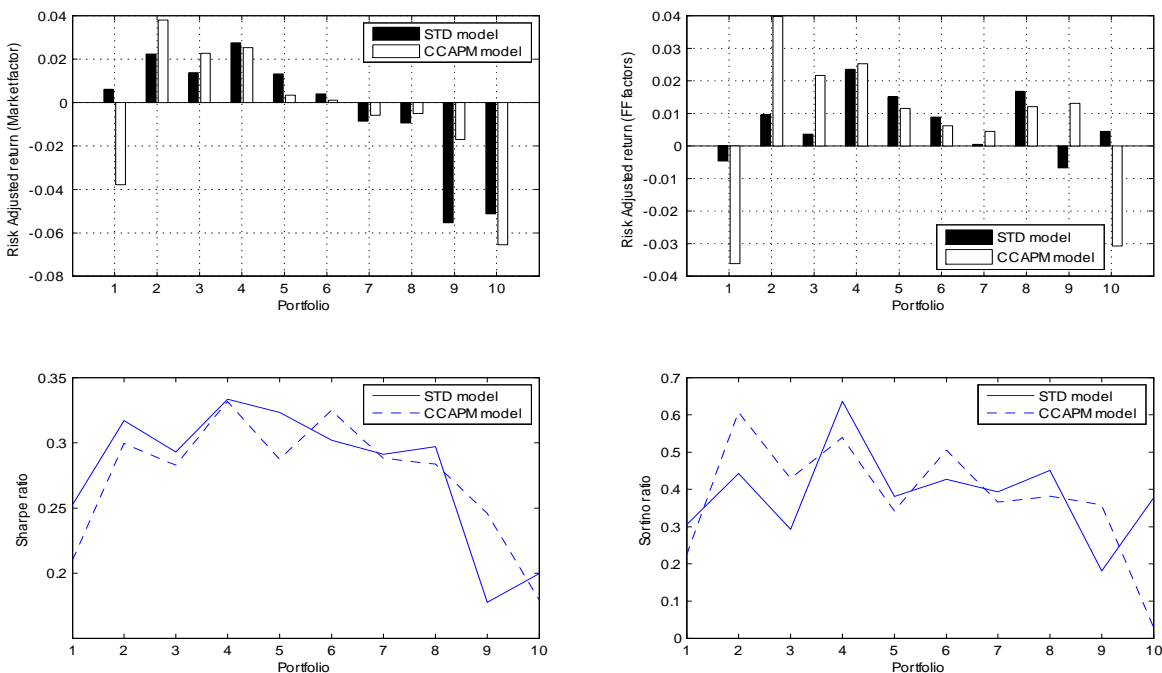
If returns on portfolios are tracked up to five years using either of these assumptions about the terminal growth rate, the usual patterns are maintained, i.e., the downward slope across portfolios in Sharpe and Sortino ratios, the downward slope across portfolios in risk adjusted (and unadjusted) returns, and portfolio 1 picks up to at least become one of the best performing portfolios after 5 years.

6.3 Arithmetic Average in Calculation of Risk Premia

In all previous analysis, I have used risk premia based on a geometric average of excess returns. I have used geometric average since this yields much lower risk premia than a arithmetic average. Hence, the choice was purely empirically based to obtain as good results for the standard model as possible. That a geometric average is often needed in order to generate sufficiently low risk premium has also been noted in the literature (see, e.g., Koller et al. (2005) and Damodaran (2006)). In this section, I implement the standard model where the cost of equity is calculated from risk premia based on an arithmetic average rather than a geometric average.

Table 14 shows the results for the standard model as well as the benchmark of the CCAPM model. The important thing to note from these results is that for all model assumptions the standard model is underpricing more severely now than in Table 7 which used the geometric average. Furthermore, the APE, *15% APE,* and *25% APE* are substantially higher. These conclusions also hold for all FF 3 factor models, and the performance of the standard model in an investment setup, as in Section 5.2, is not improved by using the arithmetic average.

6.4 Statistical Test for Model Selection

The ultimate test for a valuation model is one where the model is used to construct investment strategies that can earn abnormal profits, as performed in the previous sections. However, from a theoretical point of view it is also interesting to assess the relative performance of the models in a statistical sense. While such an analysis is very hard to perform under the very general assumptions and tests in the previous sections it can be done if one is willing to place further structure on the analysis. This involves making a series of more or less unreasonable assumptions, and therefore it provides less general results and conclusions compared to the analysis in the previous sections.

I follow the approach taken by Dechow (1994)[42] and apply a Likelihood ratio test suggested

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[42]In particular see appendix 2 of the paper.

Table 14: Performance meassure results for the standard model using CAPM based cost of equity compared to the CCAPM model

1 Factor	PE			APE				
	Mean	Median	S.D.	Mean	Median	S.D.	15% APE	25% APE
RIVCAll	0.402	0.510	0.453	0.552	0.545	0.287	0.917	0.850
RIVC5	-0.008	0.486	1.357	0.892	0.629	1.031	0.935	0.884
RIVC10	0.353	0.500	0.525	0.567	0.559	0.313	0.912	0.846
RIVC20	0.313	0.402	0.483	0.497	0.464	0.321	0.874	0.764
RIVC30	0.272	0.375	0.510	0.484	0.438	0.345	0.869	0.764
RIVGAll	0.245	0.435	0.688	0.579	0.519	0.466	0.895	0.812
RIVG5	-0.291	0.407	1.774	1.076	0.616	1.447	0.917	0.853
RIVG10	0.147	0.423	0.846	0.650	0.548	0.579	0.896	0.820
RIVG20	0.121	0.283	0.721	0.534	0.430	0.518	0.824	0.710
RIVG30	0.048	0.249	0.784	0.540	0.399	0.587	0.827	0.698
RIVIAll	0.548	0.614	0.322	0.620	0.631	0.200	0.966	0.934
RIVI5	0.393	0.603	0.729	0.698	0.647	0.468	0.958	0.922
RIVI10	0.523	0.611	0.365	0.616	0.629	0.217	0.957	0.920
RIVI20	0.500	0.568	0.345	0.582	0.588	0.223	0.950	0.906
RIVI30	0.479	0.553	0.362	0.571	0.571	0.230	0.949	0.906
CCAPM	-0.022	0.114	0.639	0.400	0.283	0.513	0.718	0.551

Note: The table presents the mean, median and standard deviation of the percentage valuation errors $(P - V)/P$ and of the absolute percentage valuation errors $|P - V|/P$. 15% APE (25% APE) shows the percentage of companies for which the valuation error is larger than 15 (25) percent. All valuations for the standard model (RIV) are based on the CAPM cost of equity. RIVC stands for constant RI, RIVG for growth in RI and RIVI for industry growth. The number in the model name in each row of column 1 indicates the number of years over which the factor risk premium is calculated, and "All" stands for using all historical data, i.e., data since 1926. The last row shows results for the CCAPM model. Unlike Table 7, the results for the standard model have been calculated using risk premia based on an arithmetic average of historical excess returns.

by Vuong (1989) for comparing models. The test provides direction concerning which of the models are closer to the "true" data generating process.

Consider the regressions (time subscripts are excluded)

$$R_i = \alpha_{STD} + \beta_{STD} \frac{P_i}{V_{i,STD}} + \varepsilon_{i,STD} \quad \varepsilon_{i,STD} \sim NIID\left(0, \sigma_{STD}^2\right),$$

and

$$R_i = \alpha_{Alt} + \beta_{Alt} \frac{P_i}{V_{i,Alt}} + \varepsilon_{i,Alt} \quad \varepsilon_{i,Alt} \sim NIID\left(0, \sigma_{Alt}^2\right),$$

where R_i is the return of asset i, P_i is market price and V_i the market price of asset i as calculated from the standard model. These regressions imply that $R_i \sim NIID\left(\alpha_{STD} + \beta_{STD} \frac{P_i}{V_{i,STD}}, \sigma_{STD}^2\right)$ in the standard model case and $R_i \sim NIID\left(\alpha_{Alt} + \beta_{Alt} \frac{P_i}{V_{i,Alt}}, \sigma_{Alt}^2\right)$ in the case of the CCAPM model. For the standard model the joint density of the observations is

$$f\left(R_1, ..., R_n\right) = \prod_{i=1}^{n} \left(\frac{1}{2\pi\sigma_{STD}^2}\right)^{1/2} \exp\left\{-\frac{e_{i,STD}^2}{2\sigma_{STD}^2}\right\},$$

where $e_{i,STD} = R_i - \alpha_{STD} - \beta_{STD}\frac{P_i}{V_{i,STD}}$. The log-likelihood is

$$\log L\left(\alpha_{STD}, \beta_{STD}, \sigma_{STD}^2\right) = \sum_{i=1}^{n}\left(-\frac{1}{2}\log\left(2\pi\sigma_{STD}^2\right) - \frac{e_{i,STD}^2}{2\sigma_{STD}^2}\right).$$

A similar log-likelihood is obtained for the CCAPM model.

The test statistic of interest is given by

$$Z = \frac{1}{\sqrt{n}}\frac{LR}{\hat{\omega}} \xrightarrow{d} N\left(0,1\right),$$

where

$$LR = \log\left(\frac{L\left(\hat{\alpha}_{STD}, \hat{\beta}_{STD}, \hat{\sigma}_{STD}^2\right)}{L\left(\hat{\alpha}_{Alt}, \hat{\beta}_{Alt}, \hat{\sigma}_{Alt}^2\right)}\right)$$

$$= \frac{n}{2}\left(\log\left(\hat{\sigma}_{Alt}^2\right) - \log\left(\hat{\sigma}_{STD}^2\right)\right) + \frac{1}{2}\sum_{i=1}^{n}\left(\frac{e_{i,Alt}^2}{\hat{\sigma}_{Alt}^2} - \frac{e_{i,STD}^2}{\hat{\sigma}_{STD}^2}\right),$$

and

$$\hat{\omega}^2 = \frac{1}{n}\sum_{i=1}^{n}\left(\log\left(\hat{\sigma}_{Alt}^2\right) - \log\left(\hat{\sigma}_{STD}^2\right) + \frac{e_{i,Alt}^2}{2\hat{\sigma}_{Alt}^2} - \frac{e_{i,STD}^2}{2\hat{\sigma}_{STD}^2}\right)^2 - \left(\frac{1}{n}LR\right)^2,$$

where $e_{i,Alt} = R_i - \alpha_{Alt} - \beta_{Alt}\frac{P_i}{V_{i,Alt}}$.

The test can conclude in favor of either model. If the Z-statistic is positive and significant, the test indicates that the standard model is the "true" model, and if the Z-statistic is negative and significant, it indicates that the CCAPM model is the "true" model.

The results of the test are presented in Table 15. Under the assumptions, as in Section 5.2, the Z-statistic is -1.8781, with a p-value of 0.0302. For the standard significance level, the test significantly implies that the model of choice is the CCAPM model. If financial and utility companies are included, as in Section 6.1, the test also significantly chooses the CCAPM model with a Z-statistic of -1.9205 and a p-value of 0.0274. The same conclusion is drawn if analyst's estimates of LTG are used in the CCAPM model together with an assumption of -5% growth in the terminal value, as in Section 6.2, or if risk premia in the standard model are calculated using arithmetic averages rather than geometric averages, as in Section 6.3. Not surprisingly the smallest p-value is obtained in the model where risk premia are calculated using arithmetric averages since the standard model performs very poorly under this assumption.

Table 15: Vuong (1989) likelihood ratio test for model selection

Assumptions	Z-statistic	p-value	Preferred model
As Section 5.2	−1.878	0.030	CCAPM
As Section 6.1	−1.921	0.027	CCAPM
As Section 6.2	−1.988	0.023	CCAPM
As Section 6.3	−2.070	0.019	CCAPM

Note: For a set of different assumptions the table presents the Z-statistic, calculated as in Vuong (1989), the corresponding p-value and the favorable model as concluded from the Z-statistic and p-value.

7   Conclusion

Analysts' forecasts of earnings growth 3-5 years ahead are without doubt too optimistic and should be implemented in valuation models with caution. Using these optimistic forecasts in valuation is crucial in the standard valuation model since the risk adjustment in this model is too aggressive. The risk adjustment is so aggressive that instead of just balancing with the error of too optimistic forecasts, it makes the standard model undervalue stocks for any set of standard assumption about the model. Rather than trying to introduce two errors to the model and hope for them to balance out, the results of this paper suggest that it is better to take a conservative approach to future growth in earnings (ignoring analysts' forecasts of long-term growth) and use a conservative risk adjustment. The results suggest that investors mainly care about the very certain short-term value creation rather than uncertain value-creation far into the future and that investors prices risk of future value creation in a very conservative manner.

Practical implementation of the CCAPM valuation model, considered in this paper, is harder than the standard valuation model, but it requires less data and as such can be used in more situations like, for example, pricing IPOs. In this paper the model is implemented trough 8 individually relatively simple steps, and I test the performance of the model against a variety of CAPM and Fama-French based valuation models. The models are tested on a large sample of US companies, using the data available when merging the Compustat, I/B/E/S and CRSP databases trough the period from 1982 to 2008.

Naturally, the most important requirement for a valuation model is that it calculates the fundamental value of the company. Three performance metrics are considered. First, median (absolute) valuation errors (compared to the market value) are compared between models. Second, the fraction of valuations for which the absolute valuation error exceeds 15% or 25% is calculated. Third, the returns from simple investment strategies based on the valuations are considered. In terms of median (absolute) valuation errors and 15% (and 25%) absolute

valuation error, the CCAPM model greatly outperforms any version of the standard model. When returns from the simple investment strategies are considered, the results are less clear, but if anything they are still in favor of the CCAPM model. Considering raw returns or returns adjusted by the market factor, both models are performing equally and very well in identifying cheap and expensive stocks. However, when returns are adjusted for risk using the 3 Fama-French risk factors, both models seem only to perform moderately. When considering Sortino ratios of the portfolios, the CCAPM model, in general, more consistently produces high values for cheap portfolios and low values for expensive portfolios, i.e., on this measure the CCAPM model outperforms the standard model.

In a robustness analysis I show that conclusions are unchanged wether financial and utility companies are included in the sample or not. I also show that if analysts' forecasts of long-term growth are utilized in both the standard and the CCAPM model, then the CCAPM model clearly outperforms any version of the standard model on all performance meassures. Large positive (negative) excess returns on cheap (expensive) portfolios based on the CCAPM model cannot be explained by neither the CAPM model or the 3 Fama-French factors. This suggests that the CCAPM model is able to utilize information contained in analysts' forecasts of long-term growth in a much better way than the standard model. Further, the robustness check shows that if risk premia in the standard model are calculated using an arithmetic mean rather than the geometric mean then the performance of the standard model is even worse.

While the results of this paper are very encouraging for valuation models based on risk adjustment in the numerator, substantial theoretical and empirical work is still left to be done. The model considered in this paper produces only little risk adjustment, and it is tempting to think that risk adjustment should play a role that falls somewhere between the CCAPM model considered in this paper and the standard CAPM approach to valuation. The model here also relies on very simple assumptions about investor preferences and time series properties of the return on equity. Several extensions to these assumptions are natural candidates for improving the performance of the risk adjustment.

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8 Appendix

Variance of $\operatorname{Re} BV$

From the equation for $\operatorname{Re} BV$ (11) the variance of $\operatorname{Re} BV$ is given by

$$\operatorname{Var}_t\left[\operatorname{Re} BV_{t,t+\tau}\right] = \operatorname{E}_t\left[\operatorname{Re} BV_{t,t+\tau} - \operatorname{E}_t\left(\operatorname{Re} BV_{t,t+\tau}\right)\right]^2 = \operatorname{E}_t\left[\sum_{s=0}^{\tau-1}(1+\mu)^{\tau-s}\omega_r^s \varepsilon_{t+\tau-s}\right]^2$$

$$= \sigma_r^2\sum_{s=0}^{\tau-1}(1+\mu)^{2(\tau-s)}\omega_r^{2s} = \sigma_r^2\left(\mu+1\right)^{2\tau}\sum_{s=0}^{\tau-1}\left(\frac{\omega_r}{\mu+1}\right)^{2s}$$

$$= \sigma_r^2\left(\mu+1\right)^{2\tau}\frac{1-\left(\frac{\omega_r}{\mu+1}\right)^{2\tau}}{1-\left(\frac{\omega_r}{\mu+1}\right)^2}.$$

The third equality follows from ε being serially uncorrelated and the last equality follows from $\sum_{k=0}^n x^k = \frac{1-x^{n+1}}{1-x}$ for $x \neq 1$. For the consumption index (12) the variance is given by

$$\operatorname{Var}_t\left[ci_{t+\tau}\right] = \operatorname{E}_t\left[ci_{t+\tau} - \operatorname{E}_t\left(ci_{t+\tau}\right)\right]^2 = \operatorname{E}_t\left[\sum_{s=0}^{\tau-1}\delta_{t+\tau-s}\right]^2 = \tau\sigma_a^2.$$

The covariance between $\operatorname{Re} BV$ and ci is given by

$$\operatorname{Cov}_t\left(\operatorname{Re} BV_{t,t+\tau}, ci_{t+\tau}\right) = \operatorname{E}\left[\left(\operatorname{Re} BV_{t,t+\tau} - \operatorname{E}_t\left[\operatorname{Re} BV_{t,t+\tau}\right]\right)\left(ci_{t+\tau} - \operatorname{E}_t\left[ci_{t+\tau}\right]\right)\right]$$

$$= \operatorname{E}\left[\left(\sum_{s=0}^{\tau-1}(1+\mu)^{\tau-s}\omega_r^s\varepsilon_{t+\tau-s}\right)\left(\sum_{s=0}^{\tau-1}\delta_{t+\tau-s}\right)\right]$$

$$= \sigma_{ra}\sum_{s=0}^{\tau-1}(1+\mu)^{\tau-s}\omega_r^s = \sigma_{ra}\left(\mu+1\right)^\tau\sum_{s=0}^{\tau-1}\left(\frac{\omega_r}{\mu+1}\right)^s$$

$$= \sigma_{ra}\left(\mu+1\right)^\tau\frac{1-\left(\frac{\omega_r}{\mu+1}\right)^\tau}{1-\frac{\omega_r}{\mu+1}}.$$

ROE convergence:

If I force RE to converge to 0 at time 12 it implies

$$RE_{12} = NI_{12} - \rho_E B_{11} = 0 \Leftrightarrow ROE_{12} = \rho_E.$$

To achieve this, I assume that ROE grows from time 5 to 12 at a constant rate, ϕ such that

$$ROE_5\left(1+\phi\right)^7 = \rho_E \Leftrightarrow \phi = \sqrt[7]{\frac{\rho_E}{ROE_5}} - 1.$$

With ϕ known, I can calculate net income and book values recursively for $t = 6, ..., 12$ as follows

$$ROE_t = \frac{NI_t}{B_{t-1}} = (1+\phi)ROE_{t-1} \Leftrightarrow NI_t = (1+\phi)ROE_{t-1}B_{t-1}, \tag{23}$$

$$B_t = B_{t-1} + (1-\delta)NI_t. \tag{24}$$

If ROE_5 is negative ($NI_5 < 0$) the above procedure is not valid. However, I can use linear interpolation

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for ROE from ROE_5 to $ROE_{12} = \rho_E$. I can then calculate net income and book values recursively for $t = 6, ..., 12$ as follows

$$ROE_t = \frac{NI_t}{B_{t-1}} = \frac{\rho_E - ROE_5}{7} + ROE_{t-1} \Leftrightarrow NI_t = \left(\frac{\rho_E - ROE_5}{7} + ROE_{t-1} \right) B_{t-1}, \qquad (25)$$

$$B_t = B_{t-1} + (1 - \delta) NI_t. \qquad (26)$$

If I force ROE to converge to the historical industry ROE, denoted by $ROE^{industry}$, I use the following procedure. I let the company ROE at $t = 5$ grow to $ROE^{industry}$ at $t = 12$. Industry ROE is given from data and I can then calculate the growth rate as

$$ROE_5 (1 + \phi)^7 = ROE^{industry} \Leftrightarrow \phi = \sqrt[7]{\frac{ROE^{industry}}{ROE_5}} - 1.$$

With ϕ known, I can calculate net income and book values recursively for $t = 6, ..., 12$ as in (23)-(24).

If $\frac{ROE_{12}^{industry}}{ROE_5} \leq 0$, I use linear interpolation for ROE from ROE$_5$ to ROE$_{12}$=ROE^{industry}. I can then calculate net income and book values recursively for $t = 6, ..., 12$ as in (25)-(26). Notice, this method can result in companies having $RE_{12} < 0$. A company cannot keep running if it is losing value and therefore if $ROE^{industry} < \rho_E$ I let ROE revert to ρ_E instead of reversion to $ROE^{industry}$.

Construction of the consumption index:

From NIPA table 2.1 I obtain the annual population (midpoint), I. From NIPA table 2.3.4 I obtain annual price index of non-durables P^N and services P^S. From NIPA table 2.3.5 I obtain annual consumption data on non-durables C^N and services C^S.

The price index for consumption of both non-durables and services is calculated as a simple weighted average of the individual price indices

$$p = p^N \frac{c^N}{c^N + c^S} + p^S \frac{c^S}{c^N + c^S}.$$

The real aggregated consumption per capita is calculated as

$$acc^R = \frac{\left(\frac{c^N}{p^N} + \frac{c^S}{p^S} \right)}{I}.$$

The real consumption index is given by

$$ci^R = \frac{1}{\gamma} \ln \left(acc^R \right),$$

and the consumption index

$$ci = ci^R + \ln (p).$$

Growth in limited participation aggregate consumption per capita, i.e., $\ln \left(\frac{acc_t^R}{acc_t^R} \right)$ is publicly available.

This data could easily have been applied since, from equation (10)

$$ci_t - ci_{t-1} = g + \delta_t \Leftrightarrow$$
$$ci_t^R + \ln(p_t) - ci_{t-1}^R - \ln(p_{t-1}) = g + \delta_t \Leftrightarrow$$
$$\frac{1}{\gamma}\ln\left(acc_t^R\right) + \ln(p_t) - \frac{1}{\gamma}\ln\left(acc_{t-1}^R\right) - \ln(p_{t-1}) = g + \delta_t \Leftrightarrow$$
$$\frac{1}{\gamma}\ln\left(\frac{acc_t^R}{acc_{t-1}^R}\right) + \ln\left(\frac{p_t}{p_{t-1}}\right) = g + \delta_t.$$

Partial effects on risk adjustment

Ignoring σ_{ra} (amounts to assuming $\sigma_{ra} > 0$) in (15) yields

$$(\mu+1)\frac{(\mu+1)^\tau - \omega_r^\tau}{1+\mu-\omega_r} = \frac{(\mu+1)^\tau - \omega_r^\tau}{1 - \omega_r(\mu+1)^{-1}}. \tag{27}$$

Differentiating with respect to μ yields

$$\frac{(\mu+1)^\tau - \omega_r^\tau}{1+\mu-\omega_r} + (\mu+1)\left(\frac{(1+\mu-\omega_r)\tau(\mu+1)^{\tau-1} - (\mu+1)^\tau + \omega_r^\tau}{(1+\mu-\omega_r)^2}\right)$$
$$= \frac{1}{(\mu-\omega_r+1)^2}\left((\mu+1)^\tau(\tau - \omega_r + \tau\mu - \tau\omega_r) + \omega_r^{\tau+1}\right).$$

I can then check the inequality

$$(\mu+1)^\tau(\tau - \omega_r + \tau\mu - \tau\omega_r) + \omega_r^{\tau+1} > 0.$$

Numerical investigation shows that for $\omega_r \geq 0$, the inequality is satisfied. For the less interesting case of $\omega_r < 0$ the sum of risk adjustment terms for $\tau = 1, ..., N$ is always positive for $\forall N$.

Differentiating (27) with respect to ω_r yields

$$\frac{-\left(1 - \omega_r(\mu+1)^{-1}\right) + (\mu+1)^{-1}\left((\mu+1)^\tau - \omega_r^\tau\right)}{\left(1 - \omega_r(\mu+1)^{-1}\right)^2}$$
$$= -\frac{\mu+1}{(\mu-\omega_r+1)^2}\left(\mu - \omega_r + \omega_r^\tau - (\mu+1)^\tau + 1\right).$$

It is seen that for $\tau = 1$, $\mu - \omega_r + \omega_r^1 - (\mu+1)^1 + 1 = 0$, and there is no effect of an increase in ω_r. For $\tau > 1$, $\omega_r > 0$ and $\mu > 0$ then $\omega_r > \omega_r^\tau$ and $(\mu+1)^\tau > \mu+1$ such that

$$\mu - \omega_r + \omega_r^\tau - (\mu+1)^\tau + 1 < 0$$

and hence

$$-(\mu+1)\left(\mu - \omega_r + \omega_r^\tau - (\mu+1)^\tau + 1\right) > 0.$$

That is, the risk adjustment is increasing in ω_r^τ if there is a positive growth in the structural level of residual income return.

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