Conservatism Correction for the Market-to-Book Ratio

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Abstract: We decompose the Market-to-Book ratio into two additive components: a Conservatism Correction factor and a Future-to-Book ratio. The Conservatism Correction factor exceeds the benchmark value of one whenever the accounting for past transactions has been subject to an (unconditional) conservatism bias. For the Future-to-Book ratio, the benchmark value is zero for firms that are not expected to make economic profits in the future. Our analysis derives a number of structural properties of the Conservatism Correction factor, including its sensitivity to growth in past investments, the percentage of investments in intangibles and the firm's cost of capital. The observed history of these variables allows us to infer the magnitude of a firm's Conservatism Correction factor, resulting in an average value for this factor that is about two-thirds of the overall Market-to-Book ratio. We test the hypothesized structural properties of the Conservatism Correction factor by forming an estimate of this variable which is obtained as the difference between the observed Market-to-Book ratio and an independent estimate of the Future-to-Book ratio.

1 Introduction

The Market-to-Book (M-to-B) ratio is commonly defined as the market value of a firm's equity divided by the book value of equity. It is well understood that this ratio exhibits considerable variation not only over time, but also at any given point in time, across industries and even across firms within the same industry. For instance, Penman (2009, p. 43) shows plots for the Market-to-Book ratio for U.S. firms, with an average value near 2.5. Among the many factors that are believed to contribute to the premium expressed in a firm's M-to-B ratio, earlier accounting and finance literature has focused on two related aspects. First, the accounting rules for financial reporting tend to understate the value of the firm's assets on the balance sheet.[1] Secondly, the market value of the firm's equity incorporates investors' assessment of the firm's potential to earn abnormal economic profits in the future.[2]

We seek to obtain theoretical and empirical insights into the M-to-B ratio by identifying a component of this ratio that is attributable to unconditional accounting conservatism. This component, which we refer to as the *Conservatism Correction* factor, is given by the replacement value of a firm's assets relative to the book value of assets as recorded under the applicable financial reporting rules. One justification for examining this ratio is that one obtains the familiar Tobin's q when M-to-B is divided by the Conservatism Correction factor. The analytical part of our paper characterizes the magnitude and structural properties of the Conservatism Correction factor in terms of its constituent variables, including the degree of accounting conservatism, past growth in investments and the cost of capital.

Our model framework builds on the notion that firms undertake a sequence of overlapping investments in productive capacity.[3] Conservative accounting in our set-up reflects that the depreciation of operating assets is accelerated relative to the benchmark of replacement cost accounting. This may be due to the lack of capitalizing some investment expenditures, possibly because they correspond to intangibles, such as R&D or advertising. Conservative accounting also arises if the straight-line depreciation rules commonly applied for operating assets are accelerated relative to the underlying useful life of an asset and its anticipated

[1]Without attempting to summarize the extensive literature on accounting conservatism, we note that parts of the theoretical literature on unconditional conservatism take a Market-to-Book ratio greater than one as a manifestation of conservative accounting; see, for example, Feltham and Ohlson (1995, 1996), Zhang (2000) and Ohlson and Gao (2006).

[2]This second aspect is usually attributed to firms with a high Tobin's q; see, for example, Lindenberg and Ross (1986), Landsman and Shapiro (1995) and Roll and Weston (2008). As stated in Ross, Westerfield and Jaffe (2005, p. 41): "Firms with high q ratios tend to be those firms with attractive investment opportunities or a significant competitive advantage."

[3]Our model builds on the earlier work of Rogerson (2008), Rajan and Reichelstein (2009) and Nezlobin (2010).

pattern of productivity declines.

The empirical part of our analysis relies on an additive decomposition of the Market-to-Book ratio. Specifically, we decompose M-to-B into the Conservatism Correction factor and a second component which will be referred to as the *Future-to-Book* ratio. Its numerator represents investors' expectations regarding the firm's future discounted economic profits. The Future-to- Book ratio is determined by both past and future investments, with the latter expected to be made optimally in light of anticipated future revenue opportunities. This ratio thus incorporates the anticipated "growth opportunities" frequently mentioned in connection with high Market-to-Book ratios. In contrast, for firms operating in a competitive environment, investors would not expect positive economic profits and therefore the M-to-B ratio reduces to the Conservatism Correction factor for those firms.[4]

Neither of the two components of the M-to-B ratio we focus on can be observed directly. However, the Conservatism Correction factor can be *estimated* based on the firm's past investments and based on direct estimates of other parameters such as the equity cost of capital and the useful life of the firm's investments. By subtracting the estimated Conservatism Correction factor from the observed M-to-B ratio, we obtain a measure of the implied Future-to-Book value. We find that on average the Conservatism Correction factor accounts for about two-thirds of the M-to-B ratio. Negative Future-to-Book values can (and do) arise because future value is partly driven by past investments that are "locked-in" irreversibly at the present date. The expected future economic profits associated with these investments may be negative if future revenue prospects are assessed less favorably at the present time compared to the time at which the investments were undertaken. One would not expect such shifts to occur on average, a prediction that is borne out by our empirical findings.

The overall Market-to-Book ratio and both of the components identified in our analysis are increasing in the degree of accounting conservatism. With regard to the percentage of investments directly expensed, M-to-B is furthermore an increasing and convex function of the percentage of investments directly expensed. Higher rates of growth in past investments tend to increase both the numerator and the denominator of the Market-to-Book ratio. Therefore the net impact of higher past growth is ambiguous. However, it can be established analytically that provided reported book values are too small relative to their replacement cost values (i.e., accounting is conservative), the Conservatism Correction factor is decreasing

[4]An alternative decomposition of the M-to-B ratio is examined in Roychowdhury and Watts (2007). They decompose equity value into net assets at historical cost, verifiable and recognized increases in the value of separable net assets, unverified and unrecognized increases in the value of separable net assets and rents. Our notion of replacement cost incorporates recognized and unrecognized increases in entry values. Our notion of future value incorporates economic rents based on past and future investments.

in higher past growth. To test this prediction empirically, we form an *estimate* of the Future-to-Book ratio by capitalizing the firm's current economic profits.[5] For the resulting implied Conservatism Correction factor, given by the difference between the Market-to-Book and the estimated Future-to-Book ratios, we do indeed find a negative association with higher growth rates in past investments. Furthermore, this negative association is more pronounced for firms that exhibit a higher percentage of intangibles investments and therefore are more prone to conservative accounting biases. Taken together, our findings speak to the interaction of accounting conservatism, past growth and anticipated future growth opportunities in shaping the M-to-B ratio.[6]

Holding all parameters fixed for a given firm, an increase in the cost of capital should lower its market value. Since book values are generally not affected by the cost of capital, one might conjecture that a higher cost of capital translates ceteris paribus into a lower M-to-B ratio. Yet such reasoning is likely to be misleading. For instance, for firms operating in a competitive industry, a higher cost of capital would translate into higher revenue in the future in order for this firm and others (whose cost of capital presumably also increased) to earn zero economic profits. In such settings, the question then becomes how the Conservatism Correction factor, which coincides with the M-to-B ratio for competitive firms, is affected by changes in the cost of capital. Intuitively, it makes sense that this correction factor is increasing in the cost of capital, because incumbent assets that were recorded at their effective replacement value now become more valuable. We demonstrate this analytically and obtain empirical support for our hypothesis by showing that the estimated Conservatism Correction factor has a positive association with the cost of capital.

The extensive literature on investments in intangibles has argued that the conservative accounting for intangibles expenditures is particularly deficient because intangibles are a source of innovation and competitive advantage.[7] Our decomposition approach allows us to examine whether firms with a high percentage of intangibles investments are indeed expected to earn higher economic profits in the future. To that end, we examine a modified version of the implied Future-to-Book ratio which corrects for the accounting bias (direct expensing)

[5]This approach is broadly consistent with the valuation model formulated in Nezlobin (2010), where the capitalization of current economic profits reflects both the discount rate and the rate of growth in the firm's sales revenues.

[6]Our finding that the Conservatism Correction factor is decreasing in past growth implies that ceteris paribus higher growth rates tend to push a stock in the direction of a "value stock", that is, a relatively high Book-to-Market ratio, contrary to the view in the "value/glamour" literature that low Book-to-Market firms are growth stocks (Lakonishok, Shleifer and Vishny, 1994).

[7]See, for instance, Lev and Sougiannis (1996), Lev (2001), Roberts (2001) and Healy, Myers and Howe (2002).

in the denominator of that ratio. Our findings show that a higher percentage of intangibles assets does not result in a higher modified Future-to-Book ratio. This finding is consistent with a perspective that views upfront investments in intangibles as a subsequent source of competitive advantage, as evidenced by higher subsequent accounting profitability. However, the combination of higher upfront investment expenditures and subsequent abnormal accounting profitability does appear to be consistent with normal economic profitability in the long run.[8]

The Market-to-Book ratio has featured prominently in earlier empirical literature in accounting and finance. One recurring theme in these studies has been the ability of the M-to-B ratio to predict future stock returns and future accounting rates of return. For instance, Penman (1996) examines how the Market-to-Book ratio and the Price-to-Earnings ratio jointly relate to a firm's future return on equity. Beaver and Ryan (2000) hypothesize that the M-to-B ratio is affected by two accounting related components which they term *bias* and *lag*, respectively. Both of these factors are conjectured to be negatively related to future accounting rates of return and the authors find empirical support for this prediction.[9] In contrast to our decomposition approach, however, both the bias and the lag component in the M-to-B ratio are extracted by a regression of the M-to-B ratio on both current and past annual security returns with fixed firm effects.

The positive association between the Book-to-Market ratio and future security returns has been documented robustly in a range of earlier studies. However, there appears to be no consensus for this relation. While Fama and French (1992, 2006) point to risk as an explanation, other authors have invoked mispricing arguments for this association; see, for instance, Rosenberg, Reid and Lanstein (1985) and Lakonishok, Shleifer and Vishny (1994). In much of the earlier finance literature, it appears that book value is merely viewed as a convenient normalization factor in the calculation of the B-to-M ratios, without recognition that the measurement bias in this variable may differ considerably across firms.[10]

In contrast to the above mentioned studies, the objective of the present paper is not an improved understanding of the relation between the Market-to-Book ratio and future returns. Our analysis seeks to identify the share of the overall premium expressed in the M-to-B ratio

[8]Of course, our arguments here are predicated on the notion that market price conveys a correct valuation of the firm's equity. Lev (2001, Ch.4) argues that the poor disclosures in connection with intangibles investments frequently leads to an undervaluation of intangibles-intensive firms.

[9]With regard to bias, this prediction is based on the steady state growth model in Ryan (1996).

[10]The addition of accounting information is, of course, the general motivation for studies like those in Piotroski (2000) and Mohanram (2005). By including firm-specific scores derived from financial statement analysis, these authors are able to refine the association between M-to-B ratios and stock returns by partitioning firms with similar B-to-M ratios into different subgroups

that is attributable to accounting conservatism and past growth in operating assets. From that perspective, our focus on past growth complements some of the recent work that has emphasized the link between conservative accounting and future earnings growth (Ohlson, 2008, and Penman and Reggiani, 2009). These papers also seek to capture the link between future growth and risk.

The remainder of this paper is organized as follows. Section 2 contains the model framework and derives a sequence of propositions. These lead to the formulation of a set of hypotheses for empirical testing in Section 3. Empirical proxies, our data set and the actual empirical results are reported in Section 4. We conclude in Section 5. Two separate Appendices contain the tables and the proofs of the propositions.

2 Model Framework

Our model examines an all equity firm that undertakes a sequence of investments in productive capacity. The assets recorded for these investments are the firm's only operating assets. In particular, we abstract from any need for working capital and assume that any cash is paid out immediately to shareholders. Accordingly, the denominator in the firm's market-to-book ratio is given by the book value of equity, which is equal to the book value of operating assets.

Capacity can be acquired at a constant unit cost. Without loss of generality, one unit of capacity requires a cash outlay of one dollar. New investments come "on-line" with a lag of L periods and have an overall useful life of T periods. Specifically, an expenditure of I_t dollars at date t will add productive capacity to produce $x_\tau \cdot I_t$ units of output at date $t+\tau$, with $x_1 = x_2 = \ldots = x_{L-1} = 0$ and $x_t > 0$ for $L \leq t \leq T$. At date T, the total capacity currently available is thus determined by the investments $(I_0, ..., I_{T-L})$. To allow for the possibility of decaying capacity, possibly to reflect the need for increased maintenance and repair over time, we specify that $1 = x_L \geq x_{L+1} \geq ... \geq x_T > 0$. For our empirical analysis, we will assume that the productivity of assets conforms to the *one-hoss shay* pattern, where $x_t = 1$ for $t > L$. [11] Alternatively, a pattern of geometric decline would set $x_t = x^{t-L}$ for some $x \leq 1$.[12]

For a given history of investments, $\mathbf{I}_T \equiv (I_0, \ldots, I_T)$, the overall productive capacity at date T becomes:

$$K_T(\mathbf{I}_T) = x_T \cdot I_0 + x_{T-1} \cdot I_1 + \ldots + x_{L+1} \cdot I_{T-L-1} + x_L \cdot I_{T-L}. \tag{1}$$

[11] Arrow (1964) also refers to this latter productivity pattern as "sudden death."

[12] In connection with solar power panels, it is commonly assumed that electricity yield is subject to "systems degradation" which is modeled as a pattern of geometrically declining capacity levels (Campbell, 2008).

The first term in the above expression reflects the final period of productive capacity for the earliest investment made by the firm (I_0). The last term represents the first period of productive use ($x_L = 1$) for the investment made at time $T - L$.

2.1 Book Values

The accounting for capacity investments is the only source of accruals in our model. In particular, all variable costs are incurred on a cash basis and can therefore, without loss of generality, be included in net sales revenue. Investments comprise expenditures for tangible and intangible assets, e.g., expenditures for plant, property and equipment, as well as expenditures for process control, training and development. Our analysis takes the ratio of tangible to intangible assets as exogenous. Consistent with the external financial reporting rules employed in most countries, we assume that intangible investments are fully expensed at the time the investment expenditure is incurred. Accordingly the initial book value per dollar of investment, bv_0, is given by:

$$bv_0 = (1 - \alpha),$$

where the parameter $\alpha \geq 0$ indicates the proportion of investment expenditures that are directly expensed. The entire depreciation schedule for capitalized investments will be denoted by $\mathbf{d} = (\alpha, d_1, d_2, \ldots d_T)$, with $\sum_{t=1}^{T} d_t = 1$. The depreciation charge in period t of the asset's existence is given by:

$$dep_t = bv_0 \cdot d_t,$$

for $1 \leq t \leq T$. Since $bv_t = bv_{t-1} - dep_t$, an asset acquired at date 0 will have a remaining book value of:

$$bv_t = bv_0 \cdot (1 - \sum_{i=1}^{t} d_i). \tag{2}$$

at date t. Given an investment history, $\mathbf{I}_T = (I_0, \ldots, I_T)$, the aggregate book value at date T is then given by:

$$BV_T(\mathbf{I}_T, \mathbf{d}) = bv_{T-1} \cdot I_1 + bv_{T-2} \cdot I_2 + \ldots + bv_0 \cdot I_T. \tag{3}$$

Among the T terms in the above representation, the first $T - L$ terms refer to investments that were in use during period T, in chronological order of their inception. The latter L terms denote the more recent investments which, because of the $L-$period lag, have not yet come into productive use.

The denominator in the Market-to-Book ratio represents the book value obtained under the applicable external financial reporting rules. We denote these asset valuation rules by $\mathbf{d}^o$ and the corresponding book value by $BV_T(\mathbf{I}_T, \mathbf{d}^o)$. In the empirical part of our analysis, we operationalize $\mathbf{d}^o$ by the financial reporting practices in the U.S. Accordingly, investments in intangibles are directly expensed and investments in plant, property and equipment are depreciated according to the straight-line rule.

2.2 Market Values

Investors are assumed to expect future investment decisions to be made so as to maximize firm value. In particular, there are no frictions due to agency problems. For reasons of parsimony, we also present the valuation problem as one of certainty, that is, investors have complete foresight of the firm's future growth opportunities. As a consequence, they anticipate the stream of future free cash flows that the firm derives from past investments in productive capacity and optimally chosen future investments.[13] Let $R_{T+t}(K_{T+t})$ denote the net revenue (operating cash flow) that the firm can obtain at date $T+t$ if it has capacity level K_{T+t} in place. The future capacity levels are a function of the investment history $\mathbf{I}_T$ and the future investment levels $\mathbf{I}_\infty \equiv (I_{T+1}, I_{T+2}, ...)$. We denote the entire sequence of investments by $\mathbf{I} \equiv (\mathbf{I}_T, \mathbf{I}_\infty)$. The firm's market value can then be expressed as:

$$MV_T(\mathbf{I}_T) = \max_{\{\mathbf{I}_\infty\}} \{ \sum_{t=1}^{\infty} [R_{T+t}(K_{T+t}(\mathbf{I}_T, \mathbf{I}_\infty)) - I_{T+t}] \cdot \gamma^t \}, \tag{4}$$

where $\gamma = \frac{1}{1+r}$ and r denotes the equity cost of capital. Let $\hat{\mathbf{I}}_\infty(\mathbf{I}_T)$ denote a sequence of future investments that maximizes (4), conditional on $\mathbf{I}_T$. The combined sequence $\hat{\mathbf{I}} \equiv (\mathbf{I}_T, \hat{\mathbf{I}}_\infty(\mathbf{I}_T))$ then achieves the firm's market value in the sense that:

$$MV_T(\mathbf{I}_T) = \sum_{t=1}^{\infty} \left[R_{T+t}(K_{T+t}(\hat{\mathbf{I}})) - \hat{I}_{T+t}\right] \cdot \gamma^t. \tag{5}$$

Our principal object of study is the *Market-to-Book* ratio:

$$MB_T = \frac{MV_T(\mathbf{I}_T)}{BV_T(\mathbf{I}_T, \mathbf{d}^o)}. \tag{6}$$

[13]Conceptually, it would not be difficult to extend our model formulation so as to include uncertainty and investors' expectations. Such an extension would, however, not serve any particular purpose for either our theoretical or our empirical analysis. We also note that our present model formulation is not suited to address issue of conditional conservatism, as considered, for instance, in Basu (1997), Watts (2003), Beaver and Ryan (2005) and Roychowdhury and Watts (2007).

2.3 Conservatism Correction

We seek to apply a correction factor to the denominator in the M-to-B ratio so as to undo any (unconditional) conservatism bias inherent in the financial accounting rules embodied in $\mathbf{d}^o$. The correction we identify generates the mapping from the M-to-B ratio to Tobin's q. Since q is defined as enterprise market value divided by the replacement cost value of the firm's assets, the conservatism correction factor for an all-equity firm must be the replacement cost of the firm's assets relative to the reported book value of the assets. To operationalize the concept of replacement cost accounting, suppose hypothetically that the firm had access to a rental market for capacity services in which suppliers provide short-term (periodic) capacity services. If such a market were competitive, suppliers would charge a rental price at which they make zero economic profits on their investments. This competitive market price would be given by:

$$c = \frac{\gamma^{-L}}{\sum_{t=L}^{T} x_t \cdot \gamma^{t-L}} = \frac{1}{\sum_{t=1}^{T} x_t \cdot \gamma^{t}}, \tag{7}$$

since the joint cost of acquiring one unit of capacity has been normalized to one.[14] Given an investment history, $\mathbf{I}_T$, the replacement value of the firm's assets is given by:

$$BV_T^*(\mathbf{I}_T) = bv_{T-1}^* \cdot I_1 + bv_{T-2}^* \cdot I_2 + \ldots + bv_0^* \cdot I_T, \tag{8}$$

where $bv_t^* = c \cdot \sum_{i=t+1}^{T} x_i \cdot \gamma^{i-t}$. To interpret the expression in (8), suppose hypothetically that there is a competitive rental market for capacity services. The replacement value of an asset acquired at date 0 will then be $bv_t^* = c \cdot \sum_{i=t+1}^{T} x_i \cdot \gamma^{i-t}$ at date t, precisely because the used asset can generate rental revenues of $x_i \cdot c$ in the future periods $\{t+1, ...T\}$.

The depreciation rule $\mathbf{d}^*$ that implements the book values $\{bv_t^*\}_{t=1}^T$ will be referred to as *replacement cost accounting.* It is readily verified that this rule requires assets to be fully capitalized, that is, $\alpha^* = 0$. Furthermore, in the one-hoss shay scenario ($x_t = 1$), the replacement cost depreciation schedule $\mathbf{d}^*$ is simply the *annuity depreciation* method. These

[14]Even without reference to a hypothetical rental market for capacity services, c can be interpreted as the unit cost of capacity that is available *for one period of time* (Arrow, 1964 and Rogerson, 2008). This is readily seen in the special case where $T = 2$ and $L = 1$. Suppose the firm seeks one more unit of capacity at date 1. At date 0 the firm then needs to acquire one more unit of capacity, but it may compensate by buying x_2 unit less at 1, buy $(x_2)^2$ more unit at date 2, and so on. The cost of this variation as of date 0, is given by:

$$\left[1 - \gamma \cdot x_2 + \gamma^2 \cdot (x_2)^2 - \gamma^3 \cdot (x_2)^3 + \gamma^4 \cdot (x_2)^4 \ldots\right] = \frac{1}{1 + \gamma \cdot x_2} = c \cdot \gamma^{-1},$$

Therefore the present value cost of this variation at date 1 is indeed c.

depreciation charges are applied to the compounded book value $bv_{L-1} = bv_0 \cdot (1+r)^{L-1}$.[15] On the other hand, it can be shown that the $\mathbf{d}^*$ rule coincides with *straight-line depreciation* if practical capacity declines linearly over time such that $x_t = 1 - \frac{r}{1+r\cdot(T-L+1)} \cdot (t-L)$ for $t \geq L$.[16]

Given the replacement cost depreciation schedule, $\mathbf{d}^*$, we can express Tobin's q as:

$$q \equiv \frac{MB_T}{CC_T},$$

where

$$CC_T \equiv \frac{BV_T(\mathbf{I}_T, \mathbf{d}^*)}{BV_T(\mathbf{I}_T, \mathbf{d}^o)} = \frac{bv^*_{T-1} \cdot I_1 + bv^*_{T-2} \cdot I_2 + \ldots + bv^*_0 \cdot I_T}{bv^o_{T-1} \cdot I_1 + bv^o_{T-2} \cdot I_2 + \ldots + bv^o_0 \cdot I_T}. \tag{9}$$

A common interpretation of Tobin' q is that it captures future growth opportunities and future profitability. More specifically, Lindenberg and Ross (1981, p. 3) state:"*..for firms engaged in positive investment, in equilibrium we expect q to exceed one by the capitalized value of the Ricardian and monopoly rents which the firm enjoys.*" To formalize this statement in the context of our model, we invoke the well-known residual income formula, which expresses market value as book value plus future discounted residual incomes (Edwards and Bell, 1961; Feltham and Ohlson, 1996). Since this identity holds irrespective of the accounting rules, we can apply it for the replacement cost accounting rule $\mathbf{d}^*$, to obtain:

$$MV_T(\mathbf{I}_T) = BV_T(\mathbf{I}_T, \mathbf{d}^*) + \sum_{t=1}^{\infty} \Big[R_{T+t}(K_{T+t}(\hat{\mathbf{I}})) - H_{T+t}(\hat{\mathbf{I}}_{T+t}, \mathbf{d}^*)\Big] \cdot \gamma^t. \tag{10}$$

Here, $H_{T+t}(\cdot)$ denotes the residual income charges in period $T+t$, that is, the sum of depreciation and imputed book value charges on all past investments that are still active at date $T+t$:

[15] When assets are not in productive use during the first L periods, they become more valuable over time. Therefore the depreciation charges in the first $L-1$ periods are negative with $d^*_t = -r \cdot (1+r)^{t-1}$ for $1 \leq t \leq L-1$. This is exactly the accounting treatment that Ehrbar (1998) recommends for so-called "strategic investments," which are characterized by a long time lag between investments and subsequent cash inflows.

[16] Our notion of replacement cost accounting differs from the concept of unbiased accounting in Feltham and Ohlson (1995, 1996), Zhang (2000) and Ohlson and Gao (2006). Their notion of unbiased accounting is that book values reflect future profitability, resulting in M-to-B ratios of 1. In the literature on ROI, the concept of unbiased accounting is operationalized by the criterion that for an individual project the accounting rate of return should be equal to the project's internal rate of return; see, for instance, Beaver and Dukes (1974), Rajan, Reichelstein and Soliman (2007) and Staehle and Lampenius (2010). Thus the accruals must generally reflect the intrinsic profitability of the project. This criterion coincides with our notion of unbiased accounting if all projects have zero NPV.

$$H_{T+t}(\mathbf{I}_{T+t}, \mathbf{d}^*) \equiv z_T(\mathbf{d}^*) \cdot I_t + \ldots + z_1(\mathbf{d}^*) \cdot I_{T+t-1}. \tag{11}$$

with $z_t^* \equiv dep_t^* + r \cdot bv_{t-1}^*$. The first term in (11) captures the depreciation and interest charge for the oldest investment undertaken at date t, while the final expression corresponds to the most recent investment at date $T+t-1$. Rogerson (2008) shows that with the replacement cost accounting rule, $\mathbf{d}^*$ in place, the residual income charges are equal to the economic cost of the capacity used in the current period:

$$H_{T+t}(\mathbf{I}_{T+t}, \mathbf{d}^*) = c \cdot K_{T+t}(\mathbf{I}_{T+t})$$

for any investment sequence $\mathbf{I}_{T+t}$. Thus the firm's market value can be expressed as the replacement cost of its existing assets, i.e., $BV_T(\mathbf{I}_T, \mathbf{d}^*)$ plus its *Future Value*:

$$FV_T(\mathbf{I}_T) \equiv \sum_{t=1}^{\infty} \Big[R_{T+t}(K_{T+t}(\hat{\mathbf{I}})) - c \cdot K_{T+t}(\hat{\mathbf{I}}) \Big] \cdot \gamma^t. \tag{12}$$

Future Value measures the stream of discounted future *economic profits*, since a firm operating under conditions of zero economic profits (zero NPV on its investment projects), will have $R_{T+t}(K) = c \cdot K$ for all K. We conclude that, consistent with the verbal intuition of Lindenberg and Ross cited above:

$$q = 1 + \frac{FV_T}{BV_T(\mathbf{I}_T, \mathbf{d}^*)},$$

provided "economic profits" are equated with "Ricardian and monopoly rents".

2.4 Structural Properties of the Conservatism Correction Factor

We now proceed to characterize the magnitude and behavior of the conservatism correction factor CC_T. To test the resulting predictions empirically, we consider an additive decomposition of the Market-to-Book ratio into CC_T and the *Future-to-Book* ratio, FB_T:

$$MB_T = CC_T + FB_T, \tag{13}$$

where

$$FB_T = \frac{FV_T(\mathbf{I}_T)}{BV_T(\mathbf{I}_T, \mathbf{d}^o)}. \tag{14}$$

It is instructive to note that the additive decomposition in (13) is one among a continuum of such decompositions. We arrived at (13) by identifying CC_T as a means of obtaining

Tobin's q from the Market-to-Book ratio. By the residual income formula in (10) , however, any depreciation rule $\mathbf{d}$ provides another additive decomposition of MB_T, with the second term given by the future discounted residual incomes divided by $BV_T(\mathbf{I}_T, \mathbf{d}^o)$. A unique feature of $\mathbf{d}^*$ and the corresponding decomposition in (13) is that the second term can genuinely be interpreted as "future value". Specifically, FV_T in (14) will be zero whenever the firm operates under conditions of zero economic profitability.

According to (13), an M-to-B ratio greater than one may reflect either a conservatism correction factor exceeding one, or a positive future value, or both. The factor CC_T will exceed one, provided the asset valuation rule $\mathbf{d}^o$ is more accelerated than the replacement cost accounting in the sense that $bv_t^o \leq bv_t^*$ for all t. In that case, $CC_T \geq 1$ as all component ratios $\frac{bv_t^*}{bv_t^o}$ in (9) are greater than or equal to 1.[17] While CC_T is a function of the accounting rules and past investments decisions, Future Value reflects both past investment decisions and anticipated future investments. In particular, FV_T need not be positive because anticipated future revenues at date T could be lower than they were at the time the investments were undertaken. A longer lag, L, between the time investment expenditures are made and the time the investments become productive tends to increase the "likelihood" for a negative FV_T. Specifically, the first L terms in FV_T, that is:

$$\sum_{t=1}^{L} \left[R_{T+t}(K_{T+t}(\hat{\mathbf{I}})) - c \cdot K_{T+t}(\hat{\mathbf{I}})\right] \cdot \gamma^t = \sum_{t=1}^{L} [R_{T+t}(K_{T+t}(\mathbf{I}_T)) - c \cdot K_{T+t}(\mathbf{I}_T)] \cdot \gamma^t$$

are determined entirely by past investment decisions. Put differently, the "option value" associated with future investments materializes only in periods beyond date $T + L$.

We now proceed to examine the impact of past growth on the conservatism correction factor CC_T. To that end, the *growth rate* in investments in period t will be denoted by λ_t. This rate is defined implicitly by:

$$(1 + \lambda_t) \cdot I_{t-1} = I_t.$$

Any investment history $\mathbf{I}_T$ induces a sequence of corresponding growth rates $\boldsymbol{\lambda}_T = (\lambda_1, .., \lambda_T)$. and conversely, any initial investment I_0 combined with growth rates $(\lambda_1, .., \lambda_T)$ defines an investment history $\mathbf{I}_T$. Therefore, the aggregate book value $BV_T(\mathbf{I}_T, \mathbf{d})$ at date T can be expressed as:

$$BV_T(\boldsymbol{\lambda}_T, \mathbf{d}^o | I_0) = I_0 \cdot \left[bv_{T-1}^o(1 + \lambda_1) + bv_{T-2}^o(1 + \lambda_1)(1 + \lambda_2) + \ldots + bv_0^o \cdot \prod_{i=1}^{T}(1 + \lambda_i)\right]. \tag{15}$$

[17]See also Proposition 2 in Staehle and Lampenius (2010).

Intuitively, the impact of growth on CC_T depends on how the constituent ratios $\frac{bv_t^*}{bv_t^o}$ change over time. To state a general result, we introduce the following notion of uniformly accelerated depreciation.

Definition: *The depreciation schedule* $\mathbf{d}^o$ *is uniformly more accelerated than the replacement cost accounting rule,* $\mathbf{d}^*$*, if:*
$z_t(\mathbf{d}^o) \geq 0$ *for* $0 \leq t \leq L-1$ *and* $\frac{z_t(\mathbf{d}^o)}{x_t}$ *is monotonically decreasing in* t *for* $L \leq t \leq T$.

For the replacement cost accounting rule, $\mathbf{d}^*$, the inequalities in the preceding Definition are met as equalities since the residual income charges are equal to the economic cost of the capacity used up in period t, that is, $z_t(\mathbf{d}^*) = c \cdot x_t$. In our empirical tests, we will assume that for financial reporting purposes, firms expense their investments in intangibles and that all capitalized operating assets are depreciated according to the straight line rule.[18] The corresponding residual income charges $z_t(\mathbf{d}^o) \geq 0$ then satisfy the criterion of being uniformly accelerated provided the productive decay of assets conforms to the one-hoss shay rule ($x_t = 1$). To see this, we note that $z_t(\mathbf{d}^o) > 0$ during the construction phase ($1 \leq t \leq L-1$), while the $z_t(\mathbf{d}^o) > 0$ decrease linearly when the asset is in use because depreciation are constant and interest charges decline linearly with time.

Proposition 1: *If* $\mathbf{d}^o$ *is uniformly more accelerated than the replacement cost accounting rule,* $\mathbf{d}^*$*, the conservatism correction factor* $CC_T(\cdot)$ *is monotone decreasing in each* λ_t.

With uniformly more accelerated accounting, higher levels of growth in past investments thus lower the conservatism correction factor, due to a smaller divergence between the stated accounting book values and the replacement cost values. In the empirical part of our study, differences in unconditional conservatism across firms emerge due to two factors: (i) discrepancies between straight-line depreciation and the depreciation schedule prescribed by replacement cost accounting and (ii) differences in the parameter α. Since the book value in the denominator MB_T is decreasing linearly in α we note the following:

Observation 1: *The Market-to-Book ratio,* MB_T *is increasing and convex in* α.

Clearly, Observation 1 applies equally to the conservatism correction factor CC_T. In conjunction with Proposition 1 we then have the following prediction regarding the interaction between conservatism and growth.

[18] The AICPA's (2007, p. 399) Accounting Trends & Techniques survey of 600 Fortune 1000 firms reports that 592 of the sample firms applied straight-line accounting in reporting the value of their operating assets.

Observation 2:

$$\frac{\partial^2}{\partial\lambda_t \partial\alpha} CC_T(\cdot) < 0.$$

What is the impact of a higher cost of capital, r, on the Market-to-Book ratio? A simple *ceteris paribus* argument suggests a negative association. Accounting book value in the denominator of MB_T is independent of r provided firms use straight-line depreciation (or any other schedule that is independent of r) for the portion of their investments that were capitalized in the first place. At the same time, the expression for MV_T in (4) is decreasing in r, because future free cash flows are discounted at a higher rate. Yet, such a simplistic ceteris paribus comparison can be misleading since a higher cost of capital is likely to result in other simultaneous changes. To illustrate, suppose again the firm operates under conditions of zero economic profits such that $FV_T = 0$ because $R_{T+t}(K) = c \cdot K$ for all K. A higher cost of capital then results in a higher unit cost of capacity c and therefore higher net-revenues that will be obtained under competitive conditions. The impact of r on MB_T then reduces to the effect of r on CC_T. Intuitively, one would expect that a higher cost of capital makes the stock of past investments, $BV_T(\mathbf{I}_T, \mathbf{d}^*)$ more valuable. This turns out to be true subject to a regularity condition on the pattern of productivity levels, $(x_L, ..., x_T)$.

Proposition 2: *Suppose that* $\mathbf{d}^o$ *is independent of* r*. Then* CC_T *is increasing in* r *provided that for all* $t \geq L$*, the pattern of productivity declines satisfies*

$$\frac{x_t}{x_{t+1}} \leq \frac{x_{t+1}}{x_{t+2}}.$$

The condition on the x_t's in the statement of Proposition 3 is sufficient, but not necessary. This condition is also not very restrictive. For instance, it is satisfied by any $\boldsymbol{x}$ vector that decreases over time in either a linear or geometric fashion. The one-hoss shay scenario, where all $x_t = 1$, is one particular admissible case.

In order to obtain sharper insights about the magnitude and behavior of CC_T, we now impose additional structure on the model: constant growth ($\lambda_t = \lambda$) and the assumption that for financial reporting purposes partial expensing (fraction $\alpha \geq 0$) is followed by straight-line depreciation over the period of productive use. The conservatism correction factor then reduces to the following simple form:

$$CC_T = \frac{BV_T^o(\mathbf{I}_T, \mathbf{d}^*)}{BV_T(\mathbf{I}_T, \mathbf{d}^o)} = c \cdot \frac{\sum_{t=L}^{T} x_t \cdot (\gamma^t - \mu^t)}{\sum_{t=1}^{T} z_t(\mathbf{d}^o) \cdot (\gamma^t - \mu^t)}, \tag{16}$$

where $\mu \equiv \frac{1}{1+\lambda}$, $z_t(\mathbf{d}^o) = r \cdot (1-\alpha)$ for $1 \leq t \leq L-1$ and

$$z_t(\mathbf{d}^o) = (1-\alpha) \cdot \left[\frac{1}{T-L+1} + r \cdot \frac{T-t+1}{T-L+1}\right] \text{ for } L \leq t \leq T. \tag{17}$$

For the one-hoss shay scenario, where $x_t = 1$ for all $L \leq t \leq T$, we note that the accounting rules in (17) entail three distinct sources of conservatism: (i) an α percentage of investments is never capitalized, (ii) asset values are not compounded during the "construction" phase in periods 1 through $L-1$ and (iii) assets are depreciated according to the straight-line rule rather than the annuity depreciation rule during their productive phase in periods L through T. Even for $\alpha = 0$, the resulting book values bv_t are strictly below the unbiased book values bv_t^*.[19] The difference between the two increases in the parameter L.

Figure 1 illustrates the magnitude of the resulting conservatism correction factor CC_T for different levels of growth. In addition, the graphs in Figure 1 are based on the following parameter specifications: $L = 1$, $r = 10\%$ and $T = 15$.

Figure 1 suggests that the impact of growth on CC_T is rather uneven in the sense that the most significant drop in CC_T occurs for moderately negative growth rates between -0.5 and zero. Thereafter CC_T quickly approaches its asymptotic value, which in all three examples is equal to $\frac{1}{1-\alpha}$. For extremely negative growth rates CC_T appears to flatten out rather than increase asymptotically without bound. Our final result shows that these observations do indeed hold at some level of generality. In deriving this result, we impose the restriction that the productive capacity of assets declines linearly over time:

$$x_t = 1 - \beta \cdot (t - L),$$

for $t \geq L$. Here, $\beta \geq 0$ captures the periodic decline in productive capacity once assets are in use. The one-hoss shay scenario corresponds to $\beta = 0$. We assume that the rate of decline is not too great, in particular that $0 \leq \beta \leq \beta^* \equiv \frac{r}{1+r\cdot(T-L+1)}$. Under these assumptions, it can be verified that the combination of partial expensing and straight line depreciation represents conservative accounting, and in fact is uniformly more accelerated than R.P.C. It thus meets the more stringent requirement in the above Definition.

It will be notationally convenient to introduce the auxiliary function:

$$h(s) \equiv \frac{s \cdot (1+s)^T}{(1+s)^T - 1},$$

[19] Informally, this inequality follows from the following two observations. (i) on the interval $[0, L-1]$ it is clearly true that $bv_t^* > bv_t^o$ (we use the shorthand $bv_t^o \equiv bv_t(\mathbf{d}^o)$); (ii) on the interval $[L, T-1]$ it must also be true that $bv_t^* > bv_t^o$, because $bv_T^* = bv_T^o = 0$ and bv_t^* is decreasing and concave on $[L, T]$, while bv_t^o is a linear function of time.

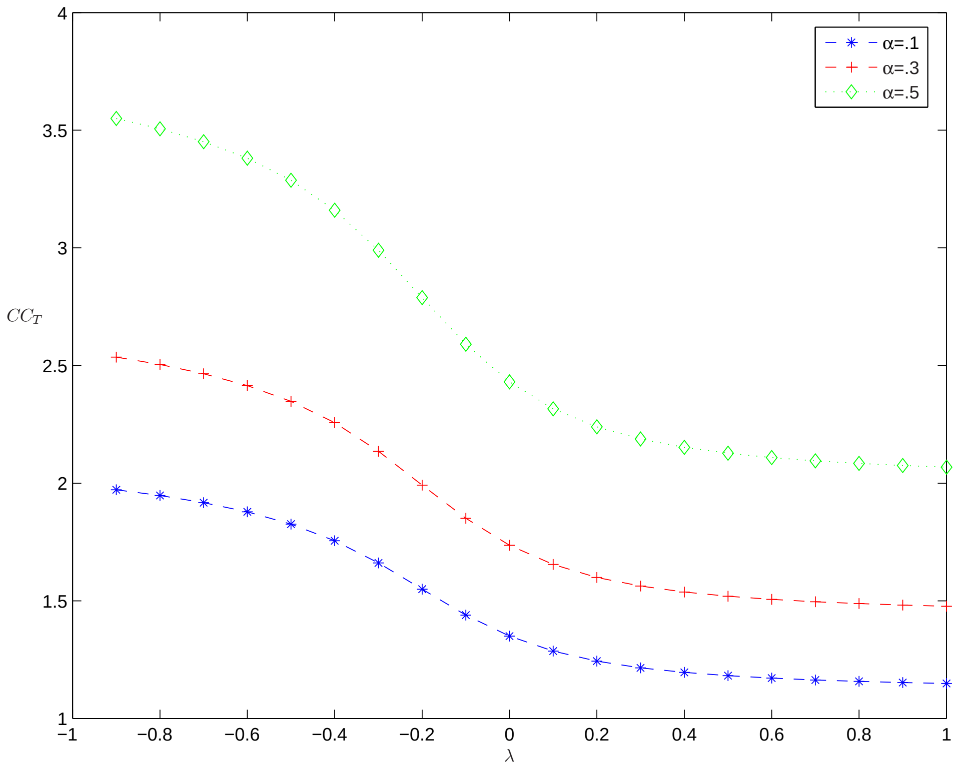

Figure 1: Conservatism Correction Factor

for s on the domain $[-1, \infty]$. The economic interpretation of $h(s)$ is that if this amount is paid annually over T years, the resulting present value is equal to 1, provided future payments are discounted at the rate s. Therefore $h(\cdot)$ is increasing and convex over its domain, with $h(-1) = 0$, $h(0) = 1/T$ and $h(\infty) = \infty$.

Proposition 3: *Suppose* $\mathbf{d}^o$ *conforms to straight-line depreciation with partial expensing,* $\lambda_t = \lambda$*, and* $x_t = 1 - \beta \cdot (t - L)$*. Then, if* $L = 1$*,*

$$\frac{2}{3} \leq \frac{CC_T(\lambda = -1) - CC_T(\lambda = 0)}{CC_T(\lambda = -1) - CC_T(\lambda = \infty)} \leq \frac{T}{T+1}.$$

If in addition the productivity pattern conforms to the one-hoss shay scenario ($\beta = 0$)*:*

(i) $\lim_{\lambda \to -1} CC_T = \frac{1}{1-\alpha} \cdot \frac{T \cdot h(r)}{(1+r)}$;

(ii) $\lim_{\lambda \to 0} CC_T = \frac{1}{1-\alpha} \cdot \frac{2 \cdot [T \cdot h(r) - 1]}{r \cdot (1+T)}$;

(iii) $\lim_{\lambda \to \infty} CC_T = \frac{1}{1-\alpha}$.

Consistent with the observations in Figure 1, Proposition 3 demonstrates that a substantial majority of the drop in CC_T as a result of increases in the growth rate occurs in the region where growth rates are negative. At least two-thirds of the reduction, and up to $\frac{T}{T+1}$ of it, takes place as the growth in new investments varies between -100% and 0%. The far smaller remainder of the decline occurs when growth varies between 0% and ∞.[20] Proposition 3 also demonstrates that for extremely negative growth rates, $\lambda \to -1$, the conservatism correction factor, CC_T flattens out and assumes finite limit values, which can be expressed in terms of the annuity function $h(\cdot)$.[21] At the other extreme, we find that, again consistent with the observations in Figure 1, CC_T converges to $\frac{1}{1-\alpha}$ for very high growth rates, irrespective of any of the other parameters.

3 Hypotheses

Our decomposition of the Market-to-Book ratio and our analytical predictions regarding its two principal components have been obtained under restrictive modeling assumptions. To align the empirical analysis as closely as possible with the above model, our focus will not be on the "raw" Market-to-Book ratio, commonly defined as the ratio of the market value of equity over the book value of equity. Since the thrust of our notion of accounting conservatism is that operating assets are understated relative to their replacement value, we shall instead examine the following *adjusted* Market-to-Book ratio:

$$MB_T = \frac{MV_T - FA_T}{BV_T^o - FA_T}, \tag{18}$$

where FA_T denotes financial assets at the observation date T. Financial assets here include working capital, such as cash and receivables, net of all liabilities, including both current liabilities and long-term debt. From that perspective, the book value of operating assets is given by $OA_T^o = BV_T^o - FA_T$.[22] Similarly, we view the market value of equity as financial assets (carried at fair value) plus the discounted value of future free cash flows. Given R.P.C. accounting, MV_T can be expressed as:

[20] For general $L > 1$, it can be shown that at least half of the drop in CC_T occurs in the range of negative growth rates, provided productivity conforms to the one-hoss shay scenario.

[21] This finding can be extended to general values of β and L. The limit values are available from the authors upon request. We note that $\lim_{\lambda \to -1} CC_T = \frac{bv_{T-1}^*}{bv_{T-1}^o}$ and $\lim_{\lambda \to \infty} CC_T = \frac{bv_1^*}{bv_1^o}$. Here, $bv_t^o \equiv bv_t(\mathbf{d}^o)$

[22] When there is no need to refer to the investment history, we shall from hereon use the more compact notation BV_T^o instead of $BV_T(\mathbf{I}_T, \mathbf{d}^o)$. Similarly, we use the shorter BV_T^* (or OA_T^*) instead of $BV_T(\mathbf{I}_T, \mathbf{d}^*)$ (or $OA_T(\mathbf{I}_T, \mathbf{d}^*)$).

$$MV_T = FA_T + OA_T^* + \sum_{t=1}^{\infty} \left[R_{T+t}(K_{T+t}(\hat{\mathbf{I}})) - c \cdot K_{T+t}(\hat{\mathbf{I}}) \right] \cdot \gamma^t, \tag{19}$$

in the presence of financial assets.[23] The adjusted Market-to-Book ratio therefore can be decomposed into:

$$MB_T = \frac{MV_T - FA_T}{BV_T^o - FA_T} = CC_T + FB_T, \tag{20}$$

where

$$CC_T = \frac{OA_T^*}{OA_T^o}, \tag{21}$$

and

$$FB_T = \frac{FV_T}{OA_T^o}. \tag{22}$$

As before, the firm's future value, FV_T, is given by the last term on the right-hand side of (19). We note in passing that the focus on adjusted rather than raw market-to-book ratios makes little difference if the raw Market-to-Book ratio is close to one.

The conservatism correction factor in (21) can be computed in terms of the firm's investment history, the percentage of investments expensed, the estimated useful life of its investments and the estimated cost of equity capital. For our calculation of CC_T we assume that the productivity of assets follows the one hoss-shay pattern and that firms rely on straight-line depreciation in reporting the value of their capitalized investments. As a consequence, the accounting is accelerated relative to the unbiased standard of R.P.C. depreciation. Proposition 1 then implies that $CC_T > 1$. From an empirical perspective, it is of interest to examine the magnitude of the implied Future-to-Book ratio, given as the residual $MB_T - CC_T$.

Hypothesis 1: *The implied Future-to-Book ratio, $MB_T - CC_T$, is positive on average.*

As argued in connection with Proposition 1, it is conceivable that a firm's future value is negative because past investment decisions, which are irreversible at date T, were made with more "exuberant" expectations about future sales revenues than investors hold at the current date T. The statement of Hypothesis 1 reflects that such a shift in expectations should not

[23]This is, of course, consistent with the studies in Feltham and Ohlson (1995) and Penman, Richardson and Tuna (2007), which presume that financial assets are carried at their fair market values on the balance sheet.

be expected on average. Hypothesis 1 also reflects that the economic profits beyond date $T + L$ reflect investments to be made optimally in future periods and the associated option value is inherently positive.

The model analyzed in Section 2 characterizes Future Value as the stream of expected future discounted economic profits, that is, the stream of residual income numbers that emerge under the R.P.C. rule. As such, it combines the firm's investment history with future decisions to be made optimally. One way to estimate Future Value therefore is to extrapolate the current economic profit at date T. To reflect the "option value" associated with future investment decisions, we adopt an asymmetric specification that takes as the estimated future value a capitalization of the current economic profit, provided that number is positive. In contrast, our measure of estimated Future Value is set equal to zero if current economic profit is negative.[24] Formally, we define the *estimated* Future-to-Book ratio as:

$$\hat{FB}_T = \frac{(1 - \tau_T) \cdot \mathcal{I}\{R_T(K_T) - c \cdot K_T\} \cdot \Gamma_\lambda^5}{OA_T^o}, \tag{23}$$

where τ_T is the statutory income tax rate in year T and $\mathcal{I}\{x\}$ is the indicator function corresponding to a call option, that is, $\mathcal{I}\{x\} = x$ if $x \geq 0$, while $\mathcal{I}(x) = 0$ if $x \leq 0$.[25] The "capitalization" factor Γ_λ^5 is given by $\sum_{i=1}^{5}(\frac{1+\lambda_3^a}{1+r})^i$, where λ_3^a denotes the geometric mean of investment growth over the past 3 years.[26] Since the economic profit $R_T(K_T) - c \cdot K_T$ is not observable, we estimate this number by making suitable adjustments to the firm's accounting income. The details of this adjustment are described in the next section summarizing our empirical findings.

If our construct of the estimated Future-to-Book ratio does indeed provide a reasonable approximation of the implied Future-to-Book ratio, we would expect both $\hat{FB}_T$ and CC_T to have significant explanatory power for the overall Market-to-Book ratio MB_T.

Hypothesis 2: *Both CC_T and $\hat{FB}_T$ have significant explanatory power for MB_T.*

We next formulate several hypotheses related to accounting conservatism. As argued in Section 2, our model has two principal sources of unconditional conservatism. The first of these is that the accounting for intangible assets results in a percentage of investments that

[24]It goes without saying that our approach to forecasting future value is ad hoc. There appear to be many promising avenues for refining the approach taken here in future studies.

[25]Firms obviously do not pay income taxes on their economic profits. Our approach of incorporating income taxes avoids the issues of estimating the firm's actual tax rate or taxes to be paid in future periods.

[26]Our capitalization of current economic profit is broadly consistent with the valuation model developed in Nezlobin (2010). We use the average growth rate over the past three years as a proxy for anticipated future growth in the firm's product markets.

is never recognized on the balance sheet. In this context, we seek to test the prediction emerging from Observation 1.

Hypothesis 3: *The Market-to-Book ratio, MB_T, is increasing and convex in α.*

The predicted impact of higher growth rates in past investments on the MB_T ratio is ambiguous in our model. While the predicted impact on CC_T is unambiguous according to Proposition 2, both the numerator and the denominator in FB_T are likely to increase with higher growth rates in the past. To isolate the impact on CC_T, we therefore consider the following *estimated* Conservatism Correction factor:

$$\hat{CC}_T = MB_T - \hat{FB}_T \tag{24}$$

To the extent that $\hat{FB}_T$ provides a suitable proxy for FB_T, we would therefore expect $\hat{CC}_T$ to be decreasing in past investment growth. Furthermore, Observation 2 shows that the negative impact of past growth on the conservatism correction factor is stronger for firms that expense a larger percentage of their investments.

Hypothesis 4: *(i) $\hat{CC}_T$ is decreasing in past investment growth. (ii) This negative association is more pronounced for firms with a higher percentage of intangibles investments.*

Proposition 3 shows that the drop in CC_T as a function of past investment growth is far more pronounced for firms with negative growth rates compared to those with positive growth rates. Figure 1 also illustrates this pattern. This leads to the following hypothesis.

Hypothesis 5: *The negative association between $\hat{CC}_T$ and past investment growth is more pronounced for firms with negative average growth in past investments than for firms with positive average growth in past investments.*

As observed in Section 2, a firm's future value, FV_T should *ceteris paribus* be decreasing in the cost of capital r, simply because future free cash flows are discounted at a higher rate. Yet the scenario of a firm operating under competitive conditions provides a good illustration of why such a ceteris paribus approach is likely to be misleading. A firm operating in a competitive environment will obtain revenues that match its entire economic cost. Therefore, a higher discount rate must lead to both higher capital costs and corresponding higher sales revenues. The impact of changes in r on the Market-to-Book ratio then reduces to the impact of r on the conservatism correction factor. Proposition 3 established that a higher cost of capital will generally result in a higher replacement cost for the firm's current assets, that, is a higher value OA_T^*. Accordingly, we formulate the following

Hypothesis 6: *$\hat{CC}_T$ is increasing in the cost of capital, r.*

Our model has viewed the proportion of intangible investments as exogenous. In particular, we have taken the perspective that economic profitability is a function of the firm's past and future investment decisions which require a given mix of tangible and intangible investments. The parameter α therefore did not enter as a direct factor in the firm's future value, FV_T. In contrast, many studies have asserted that intangibles are generally a source of innovation and competitive advantage with the promise of abnormal economic profits.[27] If true, a higher proportion of intangible investments would then tend to increase the MB_T ratio on two accounts: through conservatism and higher economic profits in the future. To examine this hypothesis, we note that the implied Future-to-Book ratio $FB_T = MB_T - CC_T$ is affected by α in the same mechanical fashion as MB_T: the denominator OA_T is linearly decreasing in α and therefore FB_T is a hyperbolic function of α. This suggests an examination of the *modified* Future-to-Book ratio, defined as:

$$\tilde{FB}_T \equiv (1 - \alpha) \cdot (MB_T - CC_T)$$

Consistent with our model formulation, we take the perspective that a higher proportion of investments in intangibles is by itself not a source of higher economic profitability in the future.

Hypothesis 7: *The modified Future-to-Book ratio, $\tilde{FB}_T$ is unrelated to α.*

4 Empirical Analysis

Our empirical analysis is designed to test the implications of the model, using a cross-section of firms over time. These tests speak directly to the central questions posed in the previous sections: What are the major components of the Market-to-Book ratio, and how do this ratio and its components relate to conservatism, growth and cost of capital. Section 4.1 discusses our empirical proxies for the theoretical constructs, Section 4.2 describes sample formation, and Section 4.3 presents the empirical methodology and the results.

[27]See, for instance, Lev (2000) and the references provided therein.

4.1 Empirical Proxies for Key Constructs

The key variables in our analysis of the Market-to-Book ratio, MB_T, are the useful life of assets, T, growth in investments, $(\lambda_1, .., \lambda_T)$, the depreciation schedule $\mathbf{d}$, the percentage of intangibles investments, α_T and the cost of capital, r_T. These variables jointly determine the two principal components of the M-to-B ratio: CC_T and FB_T. In this section, we describe our proxies for these constructs and the assumptions underlying their use. The Compustat Xpressfeed variable names used in our measures are presented parenthetically. Additional details on the measurement of these and related variables are included in Appendix 1.

As discussed in Section 3, we focus on the adjusted Market-to-Book ratio, which effectively excludes financial assets, as these are not subject to the forms of conservatism we study in this paper. The market value of equity and book value of equity are measured at the end of the fiscal year. The useful life of tangible and intangible assets, denoted as T throughout the model, is measured by taking the sum of the gross amount of property, plant and equipment and recognized intangibles divided by the annual charge for depreciation $\frac{PPEGT+INTAN}{dp}$. The depreciation variable on Compustat, dp, includes amortization of intangibles. Although our measure is admittedly an approximation, it provides an estimate of the weighted average useful life of the capitalized operating assets of the firm. This measure does not include investments that are immediately expensed such as R&D and advertising expense; effectively this assumes the omitted assets have a comparable useful life to the recognized assets.

Total investments in the observation year, T, are denoted by INV_T. This value is calculated as research and development expenses (XRD) plus advertising expenses (XAD) plus capital expenditures (CAPXV). Growth in investment in a given period, λ_T, is calculated as

$$\frac{INV_T}{INV_{T-1}} - 1.$$

We also compute the average growth rate over the past T periods by the geometric mean of the rates $(\lambda_1, ..., \lambda_T)$.

The model allows for two forms of conservatism: partial expensing of assets and conservatism in depreciation. Our measure of partial expensing, α_T, is the ratio of research and development expenses and advertising expenses to total investment, that is, $\frac{XRD+XAD}{XRD+XAD+CAPXV}$. Although there are alternative measures of conservatism in the empirical accounting literature, α_T reflects our construct of partial expensing and is therefore consistent with our theory framework.

The question of how to measure the equity cost of capital, r_T is certainly not without controversy in the accounting and finance literature. Because our focus is on understanding conservatism and its effect on Market-to-Book ratios, we want a cost of capital measure that does not rely on financial statement numbers. We therefore use the Fama and French (1992) two-factor approach, and estimate the cost of capital with the market return and firm size as factors. If the firm's implied cost of capital is missing or negative, we substitute the median cost of capital for firms in the same two-digit SIC code and year.

As indicated in Section 3, we estimate the Future-to-Book ratio at date T, FB_T, by capitalizing the firm's current economic profit, that is, $R_T(K_T) - c \cdot K_T$, provided that profit is positive. In turn, we obtain an approximation of the firm's current economic profit by current residual income, subject to a correction factor, Δ_T. This correction is intended to correct for the biases that result from the direct expensing of intangibles investments and the use of straight-line depreciation. Specifically, our proxy for $R_T(K_T) - c \cdot K_T$ is Sales_T - EconCost_T where:

$$\text{EconCost}_T = \text{Expenses}_T - dep_T + \frac{1}{\Delta_T} \cdot (dep_T + r_w \cdot OA^o_{T-1}). \tag{25}$$

Here r_w denotes the weighted average cost of capital and the correction factor Δ_T is given by:[28]

$$\Delta_T = \Gamma^T_w \cdot \frac{u_0 + u_1(1+\lambda_1) + \cdots + u_{T-1}\prod_{i=1}^{T-1}(1+\lambda_i) + \alpha_T \cdot \prod_{i=1}^{T}(1+\lambda_i)}{1 + (1+\lambda_1) + \cdots + \prod_{i=1}^{T-1}(1+\lambda_i)}, \tag{26}$$

where

$$\Gamma^T_w = \frac{1}{1+r_w} + (\frac{1}{1+r_w})^2 + ... + (\frac{1}{1+r_w})^T$$

and

$$u_t = (1-\alpha_t)[\frac{1}{T} + r_w \cdot (1 - \frac{T-1-t}{T})],$$

for $0 \leq t \leq T-1$. The correction factor Δ_T is the ratio of two historical cost figures: the numerator represents the historical cost obtained with direct expensing for investments in intangibles and straight-line depreciation of all capitalized investments; the denominator is given by the historical (economic) cost under R.P.C. accounting. This correction is applied to operating assets and is based on the weighted average cost of capital r_w. As shown in Rajan and Reichelstein (2009), this ratio exceeds (is below) one whenever the past growth rates have consistently been below (above) the cost of capital, that is, $\lambda_t \leq (\geq) r_w$ for all t.

[28]Throughout our empirical analysis, we set the lag factor L equal to 1. It seems plausible that there are significant variations in L across industries, an aspect we do not pursue in this paper.

4.2 Sample Selection

Our empirical tests employ financial statement data from Compustat Xpressfeed, and cost of capital data from the CRSP monthly returns file and K. French's website on return factors. Our sample covers all firm-year observations with available Compustat data, and covers the time period from 1962 to 2007. We exclude firm-year observations with SIC codes in the range 6000-6999 (financial companies) because the magnitude of these firms' financial assets likely precludes our detecting the effects on Market-to-Book we are interested in. This gives us a starting point of 316,896 firm-year observations, as indicated in Table 1. We impose several additional criteria to insure firms have the relevant data to measure the variables in our analysis. Specifically, we exclude observations for which market value is not available (94,185 firm-years), book value of operating assets is not available (582 firm-years), market value of net operating assets is zero or negative (13,831 firm-years), there is insufficient history for the calculation of CC_T (37,106 firm-years), the ratio of plant to total assets is less than 10% (28,859 firm-years) and total assets are less than \$4 million (6,978). These criteria yield a sample size of 135,358 firm-year observations with data on the primary variables we examine. The number of observations in any given regression varies depending on the availability of additional data necessary for the particular test as well as deletion based on outlier diagnostics.

4.3 Empirical Methodology and Results

We report results based on pooled OLS regressions. The standard errors we report are adjusted for cross-sectional and time-series dependence using the approach recommended by Peterson (2009) and Gow, Ormazabal and Taylor (2010). To minimize the influence of extreme observations in the parametric regressions, we winsorize included variables at the 2nd and 98th percentile, and exclude observations using deletion filters based on the outlier diagnostics of Belsey, Kuh and Welsch (1980). In addition, we estimate a second set of regressions where the continuous value of the independent variable is replaced with its annual percentile rank. To create these ranks, the continuous variables are sorted annually into 100 equal-sized groups. This second set of regressions makes the less restrictive assumption that the relations between the dependent and explanatory variables are monotonic (Iman and Conover, 1979). In the interests of parsimony, we present the parametric estimations in the tables and tabulate the nonparametric estimations only when they differ from the parametric results.

Descriptive Statistics

Table 2 presents the descriptive statistics for our sample. The average Market-to-Book ratio is 2.443 and the median is 1.597. The median and skewness of the distribution are consistent with the data in Penman (2009, p. 43). For the adjusted Market-to-Book ratio, MB_T, we observe an average Market-to-Book ratio for operating assets of 2.995, consistent with our presumption that financial assets have book values closer to their market values. The average cost of capital is 10.5%, which is consistent with estimates of long-term rates of return on equities by Ibbotson and Associates (2006). The average capital intensity, measured as plant to total assets, is 39.5%, confirming that plant assets are material for our sample. Advertising intensity and R&D intensity are skewed, with zero expense recognized at the 25th and 50th percentiles. The average useful life of plant and capitalized intangibles is 14.821, with a median of 14. The average (untabulated) annual fraction of partial expensing is 23.4%, with a median of 7.8%, and the growth-weighted average measure, α_T^a, is 21.3% with a median of 9.2%, consistent with skewness in advertising and R&D. The geometric mean of λ_T^a is 20.9%.

The mean of CC_T is 1.83, and the median is 1.321. As a result, the mean of FB_T, defined as the residual $MB_T - CC_T$ is 1.165. The sizable magnitude of CC_T and FB_T suggests that both conservatism and future value are substantial components of MB_T. The mean of CC_T^λ is 1.985 with a median of 1.356. Thus the calculation of the conservatism correction factor based on a measure of the average constant growth over the past T periods results in a conservatism correction of similar magnitude to that based on the full history of investments over the prior T periods. The variable $\hat{FB}_T$ in Table 2 is an estimate of future value based on estimated future economic profits. We note that $\hat{FB}_T$ has a mean of 1.040 and a median of 0.179, and thus is fairly comparable to the measure of FB_T derived by subtracting CC_T from MB_T. Panel B of Table 2 presents a correlation matrix of the variables, with Pearson correlations above the diagonal and Spearman correlations below the diagonal. The correlations provide support for a number of our measures and constructs.

Tests of Hypotheses

Our first hypothesis is that $FB_T \equiv MB_T - CC_T$ is positive on average. This is motivated by the argument that economic profits in future periods resulting from past investments should be positive on average. As documented in Table 2, the mean of FB_T is positive. Panel A of Table 3 shows that the t-statistic for the hypothesis that the mean of FB_T is greater than 0 is 10.37, which is highly significant.

Our second hypothesis is that FB_T and CC_T have significant explanatory power for MB_T. Our test of this hypothesis is based on the estimation equation:

$$MB_T = \eta_{01} + \eta_{11} \cdot CC_T + \eta_{21} \cdot \hat{FB}_T + \epsilon_1. \tag{E1}$$

We hypothesize positive coefficients on both CC_T and $\hat{FB}_T$. Panel B of Table 3 presents the estimation results. The findings indicate that both CC_T and $\hat{FB}_T$ have significant explanatory power for MB_T. The coefficient on CC_T is 0.777 with a t-statistic of 26.79. The coefficient on $\hat{FB}_T$ is 0.459, with a t-statistic of 22.91. Including both variables in the estimation causes the adjusted R^2 to climb from 15% and 18.8% for the single variable regressions to 27.7%, consistent with both variables having significant incremental explanatory power. The findings indicate that both our conservatism correction factor and our estimate of future value explain a substantial part of the variation in MB_T.

Our third hypothesis states that the Market-to-Book ratio is increasing and convex in α. We provide evidence along three different lines in our test of this hypothesis. First, we examine the relation visually by plotting the Market-to-Book ratio against α_T^a. Second, we test whether the logarithm of the Market-to-Book ratio is negatively associated with the logarithm of $1 - \alpha$. Third, we test whether the Market-to-Book ratio is increasing in $(\alpha_T^a)^2$. The corresponding estimation equations are:

$$log(MB_T) = \eta_{02} + \eta_{12} \cdot log(1 - \alpha_T^a) + \epsilon_2. \tag{E2}$$

$$MB_T = \eta'_{02} + \eta'_{12} \cdot \alpha_T^a + \eta'_{22} \cdot (\alpha_T^a)^2 + \epsilon'_2. \tag{E2'}$$

Panel A of Table 4 displays the values of α_T^a partitioned by half-deciles, and the corresponding value of MB_T for each partition. Because many firms do not report advertising or research and development expense to Compustat and therefore $\alpha = 0$, a sizable number are pooled in the bottom 6 ranks (0-5). The mean MB_T for these firms is 2.203. For observations with positive values of α, MB_T increases monotonically in α_T^a, ranging from 1.823 for the partition with mean α_T^a=0.001 to 8.095 for observations with α_T^a=0.806.

Figure 2 presents the graph of Market-to-Book values plotted against α_T^a. The figure confirms a convex relation, with MB_T increasing at an increasing rate in α_T^a. The plot findings are consistent with the estimation results for E2 and E2' in Panel B of Table 4. The first estimation documents that the relation between the log of MB_T and $log(1-\alpha_T^a)$ is highly significantly negative, with a coefficient estimate of -0.833 and t-statistic of -31.64. The second estimation also confirms a convex relation between MB_T and α_T^a, as the coefficient η_{22} is positive and significant after controlling for α_T^a. These findings provide strong support for the functional form of CC_T, which postulates that the form of correction is convex (and hyperbolic) in the degree of partial expensing.

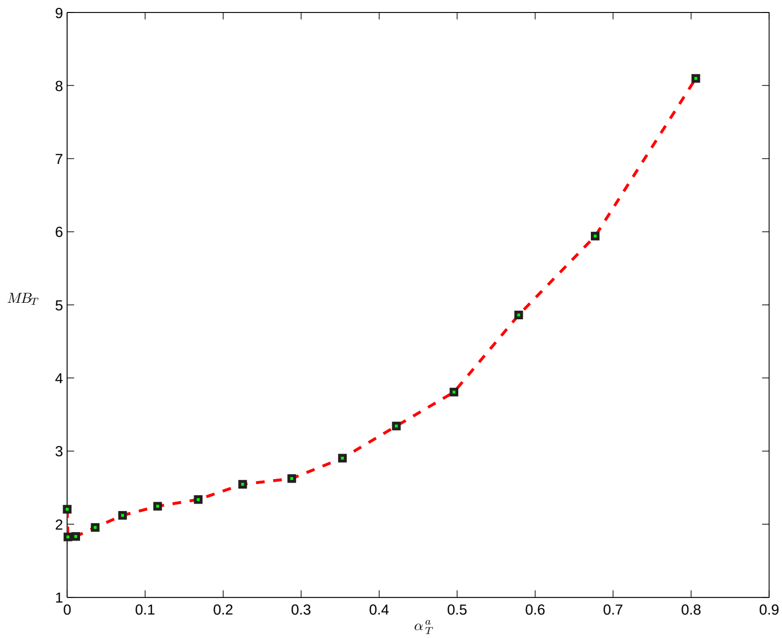

Figure 2: *Market-to-Book as a function of the percentage of investments directly expensed.*

Our fourth hypothesis concerns the relation between CC_T and past investment growth. In addition to our prediction that past growth has a negative impact on CC_T, Observation 2 notes that this negative association should be more accentuated for firms that expense a larger percentage of their investments. We base our inferences about Hypothesis 4 on the following estimation equation:

$$\hat{CC}_T = \eta_{05} + \eta_{15} \cdot \alpha_T^a + \eta_{25} \cdot \lambda_T^a + \eta_{35} \cdot r_T + \epsilon_5 \tag{E5}$$

Panel A of Table 5 presents the values of MB_T, CC_T, FB_T and their estimated counterparts: $\hat{FB}_T$ and $\hat{CC}_T \equiv MB_T - \hat{FB}_T$, partitioned by half-deciles of average growth,λ_T^a. The findings indicate a largely declining relation between the Market-to-Book ratio and growth for the first 8 half-deciles, and then an increasing relation. In contrast, our estimate of the Future-to-Book ratio based on $\hat{FB}_T$ is strictly increasing in past investment growth, consistent with the notion that investment increases in response to greater profit opportunities. The positive relation between future value and growth thus offsets the hypothesized negative relation between CC_T and investment growth. As discussed earlier, we therefore test for a negative relation between $\hat{CC}_T$ and λ_T^a to control for the opposing relation between FB_T and λ_T^a. Columns (1) and (4) of Panel B in Table 7 show that the coefficient on λ_T^a is significantly negative. This finding therefore supports Hypothesis 4 which postulates that the conservatism correction component of the M-to-B ratio is decreasing in past growth.[29]

With regard to part (ii) of Hypothesis 4, we compare the coefficient on λ_T^a for observations with α_T^a above versus those below the median. The larger negative (absolute value) coefficients for firms with a high proportion of intangibles emerges both in the parametric and nonparametric (ranks) regressions. One peculiarity in the parametric estimation results is that the coefficient on α_T^a turns negative for the subsample with low values of α_T^a. This may reflect the relatively lower power of the test resulting from the limited variation in α_T^a inherent in that subsample. Notably, the coefficient on α_T^a is positive, though insignificant, in the nonparametric results.

Hypothesis 5 is based on our analytical finding in Proposition 3: the decline in CC_T is more pronounced for firms with negative past growth in investments than for those with positive average growth. Put differently, CC_T is a monotonically decreasing function of λ_T^a, but the function flattens out for larger values of λ_T^a. In testing this prediction, we employ the same regression equation as before, except that the variable λ_T^a is partitioned into two subsamples depending on whether average past growth was positive or negative. The two corresponding variables are denoted by λ_T^{a-} and λ_T^{a+}, respectively.

$$\hat{CC}_T = \eta'_{05} + \eta'_{15} \cdot \ \alpha_T^a + \eta'_{25} \cdot \lambda_T^{a+} + \eta'_{35} \cdot \lambda_T^{a-} + \eta'_{45} \cdot r_T + \epsilon'_5 \qquad (E5')$$

Our findings in Panel C of Table 5 indicate a more negative association between past growth in investments and the estimated conservatism correction factor on account of two forces: (i) negative growth, that is $\lambda_T^a < 0$ and (ii) a high percentage of intangibles investments α_T^a. The only exception to that pattern occurs in Column (3) as we move from negative to positive past growth.

Our sixth hypothesis concerns the relation between CC_T and the cost of capital, r_T. We test whether the component of CC_T embedded in MB_T has a positive relation to the cost of capital. Accordingly, we again consider $\hat{CC}_T \equiv MB_T - \hat{FB}_T$ as our dependent variable. Our test of Hypothesis 6 is that the coefficient on r_T in estimation equation E5 is positive. The findings in Panels B and C of Table 5 indicate strong support for our hypothesis. The coefficient on r_T is positive and significant in all specifications. These findings are not due to induced measurement error in our estimate of future value, as the correlation matrix in Table 2 Panel B indicates a significant positive correlation between MB_T and r_T as well.

[29] A caveat to this interpretation is that measurement error in our estimate of $\hat{FB}_T$ is not highly correlated with past growth. To the extent such a correlation arises, it could induce a negative correlation between $\hat{CC}_T$ and past growth. We do not expect that this is driving our results as the correlation between $\hat{CC}_T$ and past growth is largely comparable to the correlation between CC_T and past growth, with Pearson and Spearman values ranging from -.03 to -.16.

Our final hypothesis states that $\tilde{FB}_T$ is unrelated to α_T^a. Our corresponding test is based on the estimation equation:

$$\tilde{FB}_T = \eta_{04} + \eta_{14} \cdot \alpha_T^a + \eta_{24} \cdot \lambda_T^a + \eta_{34} \cdot r_T + \epsilon_4 \tag{E4}$$

The modified Future-to-Book controls for the partial expensing of intangibles. Our test therefore relates an estimate of future value to the proportion of overall investments that are made in intangibles such as R&D and advertising. The findings indicate a positive relation between $\tilde{FB}_T$ and average past growth in investments, consistent with the notion that growth in investment is associated with the value of investment opportunities. The modified Future-to-book is not significantly related to the cost of capital, r_T. This finding is therefore not consistent with the notion that the discounting of cash flows by a higher cost of capital reduces future value. If investments in intangibles give rise to positive abnormal returns, we expect a positive coefficient on α_T^a, controlling for growth and the cost of capital. The findings in Table 6 indicate that modified Future-to-Book, $\tilde{FB}_T$, is in fact *negatively* related to α_T^a. The coefficient on this variable is -0.200 and the t-statistic is -2.70. The nonparametric estimation results reported in column (2) indicate a significant negative association as well. The findings suggest that controlling for the effect of partial expensing on the denominator of the Future-to-Book ratio, the association between future value and investment in intangibles is negative. The findings call into question the notion that investment in intangibles leads *ipso facto* to above-normal economic profits in the future.

5 Conclusion

This paper proposes a structural decomposition of the Market-to-Book ratio (M-to-B) into two additive component ratios: the Conservatism Correction factor (CC) and the Future-to-Book ratio (FB). Our decomposition relates to the familiar concept of Tobin's q as an all equity firm's q is given by the ratio of M-to-B to the Conservatism Correction factor. By construction, the CC factor exceeds one if the firm's operating assets are valued below their replacement cost on the balance sheet. A positive FB ratio reflects investors' expectation of a stream of positive (discounted) future economic profits.

Our empirical results document that the Conservatism Correction factor is significantly greater than one, with a mean of 1.83, and the Future-to-Book ratio is significantly positive, with a mean of 1.165. Given that the mean Market-to-Book ratio for our sample is 2.995, the findings indicate that each component is significant in explaining why the Market-to-Book ratio exceeds one. We test this directly by regressing the Market-to-Book ratio on estimates of the Conservatism Correction Factor and of Future Value. This test reveals that each component has significant explanatory power for the Market-to-Book ratio, and the combined model has an adjusted R^2 of 27.7%. These findings indicate accounting conservatism and the value of future growth opportunities each have significant impact on a firm's Market-to-Book ratio.

Our model predicts that the Market-to-Book ratio is increasing and convex in the degree of partial expensing, a prediction that is clearly confirmed by the data. Our model shows that the Conservatism Correction factor ratio is decreasing in past investment growth. We document a significant negative relation between CC_T and past growth, and, consistent with the theoretical predictions, also find a steeper negative relation for firms with a greater percentage of investments in intangibles. In addition, we predict and find that the association between M-to-B and past investment growth is more pronounced for firms with negative average growth in past investments than positive past growth. Lastly, we predict and find that the conservatism correction factor embedded in the M-to-B ratio is positively related to the cost of capital. We document this relation both for the implied Conservatism Correction factor and for the overall Market-to-book ratio.

Taken as a whole, our findings provide substantial support for the validity of the decomposition performed in this paper. Additional uses of our approach may emerge in a variety of contexts that seek to explore the relation between the M-to-B ratio and other financial ratios. As indicated in the Introduction, earlier studies have largely focused on the aggregate M-to-B ratio, even though the aggregate ratio is generally believed to reflect a confluence of several distinct factors.

6 Appendix 1-Tables

Description of Variables

MV_T	=	Market value of equity at end of fiscal year T $(CSHO * PRCC\_F)$
MB_T^{un}	=	Market value of equity at time T divided by book value of equity for fiscal year T
FA_T	=	Net financial assets at end of fiscal year t, measured as total assets minus net plant intangibles minus liabilities $(AT - PPENT - INTAN - LT)$
MB_T	=	$\frac{MV_T - FA_T}{OA_T^o} = \frac{MV_T - FA_T}{BV_T^o - FA_T}$. Adjusted Market-to-Book ratio.
OA_T^o	=	Net plant + intangibles, at end of fiscal year T, $(PPENT + INTAN)$
Total investment$_T$	=	Advertising expense plus R & D expense plus Capital expenditures for period $T-1$ to T $(XAD + XRD + CAPXV)$
α_t	=	Conservatism in fiscal year t, measured as $(XAD + XRD)/(XAD + XRD + CAPXV)$ where XAD is advertising expense, XRD is Research and Development expense, and $CAPXV$ is capital expenditures
α_T^a	=	Growth weighted average of directly expensed investments $\frac{\alpha_1(1+\lambda_1)+\cdots+\alpha_T \prod_{i=1}^{T}(1+\lambda_i)}{(1+\lambda_1)+\cdots+\prod_{i=1}^{T}(1+\lambda_i)}$
T	=	useful life of plant and intangibles, (gross plant + intangibles)/(depreciation + amortization of intangibles) measured as $(PPEGT + INTAN)$/dep.
λ_t	=	$\frac{XAD_t + XRD_t + CAPXV_t}{(XAD_{t-1} + XRD_{t-1} + CAPXV_{t-1}} - 1$
λ_T^a	=	Geometric mean of growth over T periods
λ_3^a	=	Geometric mean of growth rates $(\lambda_T, \lambda_{T-1}, \lambda_{T-2})$.

OIADP = Operating income after depreciation, amortization.

NOI = OIADP - (+) Net-Interest.

Expenses = SALE - NOI

r = cost of capital for firm i and year t, estimated with coefficients from the Fama-French (1992) two-factor model: $R_i - R_f = \delta_0 + \delta_1(R_m - R_f) + \delta_2(SMB) + \epsilon$ using CRSP monthly returns from the 5 preceding years ($t-5$ to $t-1$), and Ken French's data on market and size factors (SMB).

γ = $\frac{1}{1+r}$

Γ^n $\equiv$ $\gamma + \gamma^2 + \dots \gamma^n$

N_T = $\Gamma^1 + \Gamma^2(1+\lambda_2) + \dots \Gamma^T \prod_{i=2}^{T}(1+\lambda_i)$

D_T = $(1-\alpha_1)\left(1-\frac{T-1}{T}\right) + (1-\alpha_2)\left(1-\frac{T-2}{T}\right)(1+\lambda_2) + \dots$ $(1-\alpha_{T-1})\prod_{i=2}^{T-1}(1+\lambda_i)\cdot\left(1-\frac{1}{T}\right) + (1-\alpha_T)\prod_{i=2}^{T}(1+\lambda_i)$

CC_T = $\frac{N_T}{D_T}\cdot\frac{1}{\Gamma^T}$ where T, r, γ and λ are as defined above.

FB_T = $MB_T - CC_T$

CC_T^{λ} = Same as CC_T except that $\lambda_t = \lambda_T^a$ for all t.

τ_T = statutory income tax rate in year T

r_d = Cost of Debt: $(1-\tau_T)\cdot$ Interest Expense divided by the average of beginning and ending balance of interest-bearing debt

r_w = Weighted average cost of capital: $\frac{BV_T}{AT_T}\cdot r + \frac{AT_T - BV_T}{AT_T}\cdot r_d(1-\tau_T)$

EconCost$_T$ = Expenses$_T$ - dep_T + $\frac{1}{\Delta_T}(dep_T + r_w \cdot OA_{T-1})$. As before, dep_T includes amortization

Δ = $\Gamma_w^T \cdot \frac{u_0 + u_1(1+\lambda_1) + \dots + u_{T-1}\prod_{i=1}^{T-1}(1+\lambda_i) + \alpha_T \cdot \prod_{i=1}^{T}(1+\lambda_i)}{1 + (1+\lambda_1) + \dots + \prod_{i=1}^{T-1}(1+\lambda_i)}$

u_t = $(1-\alpha_t)[\frac{1}{T} + r_w \cdot (1 - \frac{T-1-t}{T})]$ for $0 \le t \le T-1$

Γ_w^T = $\frac{1}{1+r_w}$ + $(\frac{1}{1+r_w})^2$ +...+ $(\frac{1}{1+r_w})^T$

$\hat{FB}_T$ = Estimated Future-to-Book Value, defined as $\frac{(1-\tau_T)\cdot\mathcal{I}\{R_T(K_T) - c\cdot K_T\}\cdot\Gamma_\lambda^5}{OA_T}$

$\mathcal{I}\{x\}$ = x if $x \ge 0$ and $\mathcal{I}\{x\} = 0$ if $x \le 0$

Γ_λ^5 = Capitalization factor, given by $\sum_{i=1}^{5}\left(\frac{1+\lambda_3^a}{1+r}\right)^i$

Table 1: Sample Selection Criteria

Data available in Compustat	316,896
Market value not available	(94,185)
	222,711
Book value of operating assets not available	(582)
	222,129
Market value of net operating assets less than or equal to zero	(13,831)
	208,298
Missing data for calculation of conservatism correction, CC	(37,106)
	171,195
Ratio of Plant/Total assets less than 10%	(28,859)
	142,336
Total assets less than $4 million	(6,978)
	135,358

Table 2: Descriptive Statistics

Variable Label	N	Mean	Std Dev	25th Pctl	Median	75th Pctl
MB_T^{un}	129,772	2.443	2.853	0.987	1.597	2.708
MB_T	135,358	2.995	3.883	1.009	1.585	3.094
Total Assets	135,358	1818.070	9873.570	34.979	134.594	663.090
Capital intensity	135,358	0.395	0.219	0.216	0.341	0.545
Advertising intensity	135,233	0.086	0.182	0.000	0.000	0.067
R & D intensity	135,233	0.149	0.247	0.000	0.000	0.235
T	135,358	14.821	7.127	10.000	14.000	18.000
α_T^a	135,358	0.213	0.253	0.000	0.092	0.388
λ_T^a	135,358	0.209	0.437	0.040	0.122	0.254
λ_3^a	135,094	0.192	0.412	-0.042	0.117	0.324
r_T	135,358	0.105	0.079	0.050	0.095	0.135
CC_T	135,358	1.830	1.349	1.125	1.321	1.928
CC_T^λ	135,029	1.985	1.755	1.113	1.356	2.050
FB_T	135,358	1.165	3.619	-0.471	0.145	1.387
τ	135,358	0.412	0.054	0.370	0.370	0.480
$\hat{FB}_T$	117,960	1.040	2.650	0.000	0.179	0.888
$\hat{CC}_T$	117,960	1.583	3.578	0.581	1.108	1.956

	MB_T	r_T	T	α_T	λ_T	λ_3^a	α_T^a	λ_T^a	CC_T	CC_T^λ	FB_T	$\hat{FB}_T$	$\hat{CC}_T$
MB_T	1.00	0.09	-0.31	0.23	0.17	0.18	0.27	0.15	0.36	0.30	0.94	0.32	0.71
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
r_T	0.09	1.00	-0.17	0.09	0.05	0.12	0.11	0.07	0.16	0.14	0.05	-0.05	0.13
	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
T	-0.31	-0.17	1.00	-0.26	-0.06	-0.14	-0.28	-0.13	-0.19	-0.12	-0.23	-0.14	-0.14
	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
α_T	0.23	0.09	-0.26	1.00	-0.09	-0.04	0.90	0.00	0.74	0.72	0.06	0.06	0.23
	<.0001	<.0001	<.0001		<.0001	<.0001	0.74	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
λ_T	0.17	0.05	-0.06	-0.03	1.00	0.58	-0.05	0.55	-0.07	-0.09	0.14	0.30	-0.12
	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
λ_3^a	0.18	0.12	-0.14	0.01	0.59	1.00	-0.01	0.76	-0.05	-0.12	0.19	0.49	-0.21
	<.0001	<.0001	<.0001	0.01	<.0001		0.01	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
α_T^a	0.27	0.11	-0.28	0.91	0.00	0.01	1.00	0.01	0.82	0.72	0.09	0.07	0.27
	<.0001	<.0001	<.0001	<.0001	0.83	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
λ_T^a	0.19	0.12	-0.21	0.09	0.44	0.68	0.07	1.00	-0.03	-0.05	0.18	0.41	-0.16
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001
CC_T	0.21	0.31	-0.15	0.82	-0.09	-0.13	0.87	-0.14	1.00	0.89	0.02	0.00	0.32
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	0.74	<.0001
CC_T^λ	0.17	0.27	-0.12	0.82	-0.18	-0.30	0.81	-0.13	0.92	1.00	-0.01	-0.02	0.27
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		0.00	<.0001	<.0001
FB_T	0.84	-0.01	-0.22	-0.12	0.20	0.22	-0.10	0.22	-0.19	-0.20	1.00	0.33	0.64
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001
$\hat{FB}_T$	0.33	-0.15	-0.07	0.10	0.32	0.37	0.09	0.31	-0.04	-0.07	0.33	1.00	-0.44
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001
$\hat{CC}_T$	0.72	0.15	-0.16	0.13	-0.08	-0.14	0.17	-0.08	0.20	0.19	0.64	-0.22	1.00
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	

Table 3:

Panel A: Fractiles of the distribution of the Market-to-Book ratio, Conservatism Correction and Future-to-Book value.

Variable	N	Mean	Std Dev	25th Pctl	Median	75th Pctl
MB_T^{un}	129,772	2.443	2.853	0.987	1.597	2.708
MB_T	135,358	2.995	3.883	1.009	1.585	3.094
CC_T	135,358	1.830	1.349	1.125	1.321	1.928
FB_T	135,358	1.165	3.619	-0.471	0.145	1.387
$\hat{FB}_T$	117,960	1.040	2.650	0.000	0.179	0.888

Panel B: Tests of hypothesized values for CC_T and FB_T

Variable	Mean	Hypothesized Value	Standard Error of Mean	t-statistic
CC_T	1.830	1	0.031	27.57*
FB_T	1.165	0	0.112	10.37*

Panel C: Estimation results from regression of Market-to-Book on the Conservatism Correction factor and estimated Future-to-Book ratio. Coefficients are shown with t-statistics in parentheses.

$$MB_T = \eta_{01} + \eta_{11} \cdot CC_T + \eta_{21} \cdot \hat{FB}_T + \epsilon_1. \tag{E1}$$

Variables	(1)	(2)	(3)
Intercept	0.908	1.649	0.604
	(15.73)	(28.15)	(11.99)
CC_T	0.777		0.766
	(26.79)		(22.43)
$\hat{FB}_T$		0.457	0.454
		(22.91)	(23.54)
Adjusted R^2	0.150	0.188	0.277
n	127,594	112,024	111,742

*The probability value of the test statistic is less than .0001.

Table 4: The Relation between α and MB_T.

Panel A: Mean Values of Selected Variables Ranked by Half-deciles of α_T^a

Rank	n	α_T^a	MB_T	CC_T	FB_T	FB_T^*
3	45564	0.000	2.203	1.159	1.044	1.044
6	1811	0.001	1.823	1.175	0.648	0.648
7	6768	0.011	1.832	1.177	0.655	0.640
8	6768	0.036	1.953	1.207	0.747	0.708
9	6768	0.071	2.118	1.252	0.866	0.782
10	6768	0.116	2.243	1.319	0.924	0.789
11	6768	0.168	2.334	1.397	0.937	0.754
12	6768	0.225	2.544	1.502	1.041	0.789
13	6768	0.288	2.621	1.645	0.976	0.702
14	6768	0.353	2.901	1.805	1.097	0.713
15	6768	0.422	3.339	2.021	1.319	0.782
16	6768	0.496	3.805	2.325	1.480	0.757
17	6768	0.579	4.860	2.771	2.089	0.888
18	6768	0.677	5.938	3.636	2.302	0.768
19	6767	0.806	8.095	6.426	1.669	0.359

Panel B:

$$log(MB_T) = \eta_{02} + \eta_{12} \cdot log(1 - \alpha_T^a) + \epsilon_2. \qquad \text{(E2)}$$

$$MB_T = \eta'_{02} + \eta'_{12} \cdot \alpha_T^a + \eta'_{22} \cdot (\alpha_T^a)^2 + \epsilon'_2. \qquad \text{(E2}'\text{)}$$

Variables	(1)	(2)
Intercept	0.329	1.817
	(9.97)	(34.51)
$\log(1 - \alpha_T^a)$	-0.833	
	(-31.64)	
α_T^a		-1.287
		(-5.12)
α^2		7.011
		(18.05)
Adjusted R^2	0.206	0.173
n	127,796	127,726

Table 5: The Relation between Adjusted Market-to-Book and Growth

Panel A: Market-to-Book partitioned by λ.

Rank	n	λ_T^a	MB_T	CC_T	FB_T	$\hat{FB}_T$	$\hat{CC}_T$
0	6767	-0.307	2.789	1.945	0.845	0.087	2.226
1	6768	-0.099	2.578	1.903	0.675	0.241	1.968
2	6768	-0.034	2.514	1.910	0.604	0.329	1.881
3	6768	0.003	2.454	1.865	0.589	0.383	1.812
4	6768	0.029	2.294	1.768	0.526	0.381	1.688
5	6768	0.049	2.328	1.776	0.552	0.450	1.653
6	6768	0.066	2.283	1.759	0.524	0.473	1.567
7	6768	0.082	2.281	1.746	0.536	0.499	1.529
8	6768	0.097	2.334	1.748	0.586	0.580	1.524
9	6768	0.113	2.475	1.796	0.679	0.656	1.545
10	6768	0.131	2.518	1.798	0.720	0.722	1.544
11	6768	0.150	2.707	1.787	0.920	0.837	1.586
12	6768	0.173	2.873	1.838	1.035	0.878	1.679
13	6768	0.200	3.099	1.902	1.197	1.016	1.704
14	6768	0.234	3.310	1.901	1.410	1.104	1.780
15	6768	0.279	3.578	1.929	1.650	1.238	1.890
16	6768	0.342	3.770	1.921	1.850	1.375	1.932
17	6768	0.441	4.170	1.843	2.328	1.665	1.943
18	6768	0.634	4.479	1.832	2.647	2.478	1.403
19	6767	1.598	5.068	1.637	3.432	5.728	-1.255

Panel B:

$$\hat{CC}_T = \eta_{05} + \eta_{15} \cdot \ \alpha_T^a + \eta_{25} \cdot \lambda_T^a + \eta_{35} \cdot r_T + \epsilon_5 \tag{E5}$$

Estimation results for regression of the estimated Conservatism Correction factor, $\hat{CC}_T$, on average growth.

	1	2	3	4	5	6
		$\alpha_T^a > 0.09$	$\alpha_T^a \leq 0.09$		$\alpha_T^a > 0.09$	$\alpha_T^a \leq 0.09$
Intercept	0.853	0.109	1.009	36.918	20.640	42.162
	(10.25)	(0.74)	(17.47)	(20.37)	(7.90)	(25.07)
α_T^a	1.716	3.205	-1.752	0.159	0.363	0.023
	(13.08)	(17.06)	(-2.09)	(5.36)	(8.72)	(0.80)
λ_T^a	-1.200	-1.424	-0.531	-0.076	-0.092	-0.073
	(-12.88)	(-8.32)	(-10.11)	(-4.45)	(-4.33)	(-4.53)
r_T	3.016	4.058	2.041	0.716	0.211	0.144
	(5.10)	(4.93)	(5.09)	(15.65)	(14.92)	(12.84)
Adjusted R^2	0.124	0.146	0.036	0.061	0.073	0.028
n	110,183	53,353	56,563	117, 959	57,713	60,245

Panel C:

$$\hat{CC}_T = \eta'_{05} + \eta'_{15} \cdot \ \alpha^a_T + \eta'_{25} \cdot \lambda^{a+}_T + \eta'_{35} \cdot \lambda^{a-}_T + \eta'_{45} \cdot r_T + \epsilon'_5 \qquad (E5')$$

Estimation results for regression of the estimated Conservatism Correction factor, $\hat{CC}_T$, on average growth, partitioned into positive and negative average growth: λ^{a+}_T and λ^{a-}_T.

	1	2	3	4	5	6
		$\alpha^a_T > 0.09$	$\alpha^a_T \leq 0.09$		$\alpha^a_T > 0.09$	$\alpha^a_T \leq 0.09$
Intercept	0.816	0.025	1.013	34.577	17.699	40.014
	(9.21)	(0.16)	(16.69)	(23.30)	(7.46)	(27.74)
α^a_T	1.670	3.206	-1.832	0.154	0.355	0.019
	(12.93)	(16.96)	(-2.27)	(5.15)	(8.47)	(0.68)
λ^{a-}_T	-0.862	-2.079	-0.386	-14.811	-29.092	-9.099
	(-5.49)	(-6.62)	(-3.53)	(-5.33)	(-5.54)	(-3.39)
λ^{a+}_T	-0.696	-0.869	-0.531	-6.428	-7.144	-6.438
	(-11.22)	(-6.78)	(-10.61)	(-7.35)	(-5.35)	(-7.66)
r_T	2.843	3.940	2.072	0.175	0.210	0.144
	(4.86)	(4.87)	(5.23)	(15.69)	(14.96)	(12.81)
Adjusted R^2	0.114	0.141	0.056	0.066	0.076	0.036
n	109.827	53,310	56,572	117,959	57,713	60, 245

Table 6: The Relation between the modified Future-to-Book ratio, $\tilde{FB}_T$, and α_T^a

$$\tilde{FB}_T = \eta_{04} + \eta_{14} \cdot \alpha_T^a + \eta_{24} \cdot \lambda_T^a + \eta_{34} \cdot r_T + \epsilon_4 \quad \text{(E4)}$$

Variables	(1)	(2)
Intercept	0.289	42.498
	(4.78)	(37.49)
α_T^a	-0.200	-0.143
	(-2.70)	(-10.40)
λ_T^a	1.145	0.281
	(21.38)	(23.26)
r_T	-0.174	0.004
	(-0.45)	(0.26)
Adjusted R^2	0.067	0.089
n	129,629	135,358

Model (2) is estimated with ranks of the dependent and independent variables, where each variable is ranked into groups of 100 by year.

7 Appendix 2-Proofs

Proof of Proposition 1: We can set α to 0 without loss of generality for this proof. From (9), CC_T equals (after dividing through by the common term $I_0 \cdot (1+\lambda_1)$):

$$CC_T = \frac{BV_T(\mathbf{I}_T, \mathbf{d}^*)}{BV_T(\mathbf{I}_T, \mathbf{d}^o)} = \frac{bv^*_{T-1} + bv^*_{T-2} \cdot (1+\lambda_2) + \ldots + bv^*_0 \cdot \prod_{i=2}^{T}(1+\lambda_i)}{bv^o_{T-1} + bv^o_{T-2} \cdot (1+\lambda_2) + \ldots + bv^o_0 \cdot \prod_{i=2}^{T}(1+\lambda_i)}. \tag{27}$$

This ratio is decreasing in λ_t if and only if the sequence $\frac{bv^*_t}{bv^o_t}$ is an increasing function of t.[30] Given the replacement cost accounting rule, $\mathbf{d}^*$, we know from (7) and (12) that $z^*_t = x_t = 0$ for $1 \leq t \leq L-1$ and $z^*_t = c \cdot x_t$ for $L \leq t \leq T$. It follows that for all t, $z^*_t = c \cdot x_t$, . We recall the following identity linking book values to future "residual income charges".

$$bv_t(\mathbf{d}) = \sum_{i=t+1}^{T} z_i(\mathbf{d}) \cdot \gamma^{i-t}.$$

Denoting $bv^o_t \equiv bv_t(\mathbf{d^o})$, we have:

$$\frac{bv^*_t}{bv^o_t} = \frac{\sum_{i=t+1}^{T} z_i(\mathbf{d}^*) \cdot \gamma^{i-t}}{\sum_{i=t+1}^{T} z_i(\mathbf{d^o}) \cdot \gamma^{i-t}} = \frac{c \cdot \sum_{i=t+1}^{T} x_i \cdot \gamma^i}{\sum_{i=t+1}^{T} z_i(\mathbf{d^o}) \cdot \gamma^i}. \tag{28}$$

Analogously, we have:

$$\frac{bv^*_{t-1}}{bv^o_{t-1}} = \frac{c \cdot \sum_{i=t}^{T} x_i \cdot \gamma^i}{\sum_{i=t}^{T} z_i(\mathbf{d^o}) \cdot \gamma^i} = \frac{c \cdot \left[x_t \cdot \gamma^t + \sum_{i=t+1}^{T} x_i \cdot \gamma^i\right]}{z_t(\mathbf{d^o}) \cdot \gamma^t + \sum_{i=t+1}^{T} z_i(\mathbf{d^o}) \cdot \gamma^i}. \tag{29}$$

To establish that (28) $\geq$ (29), we note that for $1 \leq t \leq L-1$, the inequality follows immediately since $x_t = 0$ and $z_t(\mathbf{d^o}) \geq 0$ (see Definition 2). For $t \geq L$, the result holds if and only if

$$\frac{z_t(\mathbf{d^o})}{x_t} \geq \frac{\sum_{i=t+1}^{T} z_i(\mathbf{d^o}) \cdot \gamma^i}{\sum_{i=t+1}^{T} x_i \cdot \gamma^i} \tag{30}$$

[30] A proof of this assertion can be found in Claim 2 in the proof of Proposition 3 in Rajan and Reichelstein (2009).

We demonstrate that (30) is true by a process of induction. For $t = T - 1$, (30) requires:

$$\frac{z_{T-1}(\mathbf{d^o})}{x_{T-1}} \geq \frac{z_T(\mathbf{d^o})}{x_T},$$

which is true as $\frac{z_t(\mathbf{d^o})}{x_t}$ decreases in t. Now, suppose that (30) holds for t = k. Then, for t=k-1,

$$\frac{z_{k-1}(\mathbf{d^o})}{x_{k-1}} \geq \frac{z_k(\mathbf{d^o})}{x_k} = \frac{z_k(\mathbf{d^o}) \cdot \gamma^k}{x_k \cdot \gamma^k} \geq \frac{z_k(\mathbf{d^o}) \cdot \gamma^k + \sum_{i=k+1}^{T} z_i(\mathbf{d^o}) \cdot \gamma^i}{x_k \cdot \gamma^k + \sum_{i=k+1}^{T} x_i \cdot \gamma^i} = \frac{\sum_{i=k}^{T} z_i(\mathbf{d^o}) \cdot \gamma^i}{\sum_{i=k}^{T} x_i \cdot \gamma^i},$$

where the second inequality arises from the induction hypothesis. We have thus shown that (30) holds. To conclude, note that we have stated the proof in terms of weak inequalities. However, if either $z_t(\mathbf{d^o}) > 0$ for some $t \leq L - 1$ or $\frac{z_t(\mathbf{d^o})}{x_t}$ strictly decreases in t for $t \geq L$, it follows that $\frac{bv_t^*}{bv_t(\mathbf{d^o})}$ strictly increases for some subset of values of t, and therefore that CC_T is monotone decreasing in each λ_t. ■

Proof of Proposition 2: Consider CC_T as represented in equation (27). The denominator, BV_T, is determined by the depreciation scheme under consideration and is independent of the cost of capital, r. So it is sufficient to show that the numerator, BV_T^*, increases in r, or, equivalently, that it decreases in γ. We use the following formulation of $BV_T(\mathbf{I}_T, \mathbf{d}^*)$:

$$BV_T(\mathbf{I}_T, \mathbf{d}^*) = bv_{T-1}^* \cdot I_1 + bv_{T-2}^* \cdot I_2 + \ldots + bv_0^* \cdot I_T.$$

As in the proof of Proposition 2, we set $bv_t^* = c \cdot \sum_{i=t+1}^{T} x_i \cdot \gamma^{i-t}$. $BV_T(\mathbf{I}_T, \mathbf{d}^*)$ therefore equals:

$$c \cdot \left[I_1 \cdot \sum_{i=T}^{T} x_i \cdot \gamma^{i-(T-1)} + I_2 \cdot \sum_{i=T-1}^{T} x_i \cdot \gamma^{i-(T-2)} + \ldots + I_T \cdot \sum_{i=1}^{T} x_i \cdot \gamma^i \right].$$

As $c = \frac{1}{\sum_{i=L}^{T} x_i \cdot \gamma^i}$, we need to show that the following expression decreases in γ:

$$\frac{I_1 \cdot x_T \cdot \gamma + I_2 \cdot \sum_{i=T-1}^{T} x_i \cdot \gamma^{i-(T-2)} + \ldots + I_T \cdot \sum_{i=1}^{T} x_i \cdot \gamma^i}{\sum_{i=L}^{T} x_i \cdot \gamma^i}. \tag{31}$$

We do so one term at a time. Ignoring the positive constant I_t, an arbitrary term in (31) is of the form:

$$\frac{\sum_{i=k}^{T} x_i \cdot \gamma^{i-k+1}}{\sum_{i=L}^{T} x_i \cdot \gamma^i}, \quad k \in \{1, 2, \ldots, T\}. \tag{32}$$

Consider $k \leq L$. As $x_1 = \ldots = x_{L-1} = 0$, (32) is equivalent to:

$$\frac{\sum_{i=L}^{T} x_i \cdot \gamma^{i-k+1}}{\sum_{i=L}^{T} x_i \cdot \gamma^{i}} = \gamma^{-(k-1)}, \tag{33}$$

which is decreasing in γ as $k \geq 1$.

For $k > L$, (32) decreases in γ if and only if

$$\left(\sum_{i=L}^{T} x_i \cdot \gamma^{i}\right) \cdot \left[\sum_{i=k}^{T} x_i \cdot (i-k+1) \cdot \gamma^{i-k}\right] \leq \left[\sum_{i=k}^{T} x_i \cdot \gamma^{i-k+1}\right] \cdot \left(\sum_{i=L}^{T} x_i \cdot i \cdot \gamma^{i-1}\right), \text{ or}$$

$$\frac{\sum_{i=L}^{T} x_i \cdot \gamma^{i-1}}{\sum_{i=L}^{T} x_i \cdot i \cdot \gamma^{i-1}} \leq \frac{\sum_{i=k}^{T} x_i \cdot \gamma^{i-k}}{\sum_{i=k}^{T} x_i \cdot (i-k+1) \cdot \gamma^{i-k}}. \tag{34}$$

With regard to the left-hand side of (34), note that:

$$\frac{\sum_{i=L}^{T} x_i \cdot \gamma^{i-1}}{\sum_{i=L}^{T} x_i \cdot i \cdot \gamma^{i-1}} < \frac{\sum_{i=L}^{L+T-k} x_i \cdot \gamma^{i-1}}{\sum_{i=L}^{L+T-k} x_i \cdot i \cdot \gamma^{i-1}}$$

since each additional term in the former has a numerator-to-denominator ratio of less than $1/(L+T-k)$. So it is sufficient to demonstrate that

$$\begin{aligned} \frac{\sum_{i=L}^{L+T-k} x_i \cdot \gamma^{i-1}}{\sum_{i=L}^{L+T-k} x_i \cdot i \cdot \gamma^{i-1}} &\leq \frac{\sum_{i=k}^{T} x_i \cdot \gamma^{i-k}}{\sum_{i=k}^{T} x_i \cdot (i-k+1) \cdot \gamma^{i-k}} \\ \Leftrightarrow \quad \frac{\sum_{i=L}^{L+T-k} x_i \cdot \gamma^{i-L}}{\sum_{i=k}^{T} x_i \cdot \gamma^{i-k}} &\leq \frac{\sum_{i=L}^{L+T-k} x_i \cdot i \cdot \gamma^{i-L}}{\sum_{i=k}^{T} x_i \cdot (i-k+1) \cdot \gamma^{i-k}} \end{aligned} \tag{35}$$

Since x_i/x_{i+1} increases in i, we know that $\frac{x_L}{x_k} \leq \frac{x_{L+1}}{x_{k+1}} \cdots \leq \frac{x_{L+T-k}}{x_T}$. The left-hand side of (35) places equal weight on these ratios, which implies that

$$\frac{\sum_{i=L}^{L+T-k} x_i \cdot \gamma^{i-L}}{\sum_{i=k}^{T} x_i \cdot \gamma^{i-k}} < \frac{\sum_{i=L}^{L+T-k} x_i \cdot (i-L+1) \cdot \gamma^{i-L}}{\sum_{i=k}^{T} x_i \cdot (i-k+1) \cdot \gamma^{i-k}}, \tag{36}$$

since the expression on the right-hand side of (36) places increasingly higher weights on the higher ratios. Finally, $L \geq 1$ implies that the right-hand side of (35) exceeds the right-hand side of (36). Hence, the inequality in (35) holds, and we have shown that $BV_T(\mathbf{I}_T, \mathbf{d}^*)$ (and hence CC_T) increases in r. ■

Proof of Proposition 3: For $L = 1$, we have $x_t = 1 - \beta \cdot (t-1)$. The capital charges in (17) simplify to:

$$z_t = \frac{1-\alpha}{T} \cdot [1 + r \cdot (T - t + 1)]$$

Using these expressions, as well as the definition of c, we can rewrite CC_T in (16) as:

$$CC_T = \frac{T}{\sum_{i=1}^{T} [1 - \beta \cdot (i-1)] \cdot \gamma^i} \cdot \frac{\sum_{i=1}^{T} [1 - \beta \cdot (i-1)] \cdot (\gamma^i - \mu^i)}{\sum_{i=1}^{T} [1 + r \cdot (T - i + 1)] \cdot (\gamma^i - \mu^i)} \cdot \frac{1}{1-\alpha} \tag{37}$$

Expanding this expression, it can then be shown that the limit values of the CC_T function are as follows:

$$\begin{aligned}
\lim_{\lambda \to -1} CC_T(\cdot) &= \left(\frac{1}{1-\alpha}\right) \cdot \frac{T \cdot r^2 \cdot (1+r)^{T-1} \cdot [1 - \beta \cdot (T-1)]}{(r-\beta) \cdot [(1+r)^T - 1] + \beta \cdot r \cdot T} \\
\lim_{\lambda \to 0} CC_T(\cdot) &= \left(\frac{1}{1-\alpha}\right) \cdot \left[\frac{T \cdot [2 + \beta \cdot (1-T)] \cdot r^2 \cdot (1+r)^T}{(r-\beta) \cdot [(1+r)^T - 1] + \beta \cdot r \cdot T} - 2\right] \cdot \frac{1}{r \cdot [T+1]} \\
\lim_{\lambda \to \infty} CC_T(\cdot) &= \frac{1}{1-\alpha}
\end{aligned} \tag{38}$$

The limit results for the $\beta = 0$ case follow directly from these expressions.

We next prove the claim regarding the bounds on the ratios of the CC_T variables. Note that the term $1/(1-\alpha)$ enters in a multiplicative fashion in each of the CC_T expressions in (38) and, as such, can be ignored. Also, when $T = 2$, direct computations on (38) reveal that the ratio in question always equals $\frac{2}{3}$. We therefore restrict attention to values of $T > 2$. We first show the upper bound result that

$$\frac{CC_T(\lambda = -1) - CC_T(\lambda = 0)}{CC_T(\lambda = -1) - CC_T(\lambda = \infty)} \leq \frac{T}{T+1}.$$

To do so, we will demonstrate the equivalent result that

$$\frac{CC_T(\lambda = 0) - CC_T(\lambda = \infty)}{CC_T(\lambda = -1) - CC_T(\lambda = \infty)} \geq \frac{1}{T+1}. \tag{39}$$

Using the limits in (38), (39) reduces to the following inequality:

$$
\begin{aligned}
&(T+1)\cdot\left[\frac{1}{r(1+T)}\cdot\frac{Tr^2(1+r)^T(2+\beta-\beta T)}{\beta rT+(r-\beta)[(1+r)^T-1]}-\frac{2}{r(1+T)}-1\right]\\
\geq\;& \frac{Tr^2(1+r)^{T-1}[1+\beta-\beta T]}{\beta rT+(r-\beta)[(1+r)^T-1]}-1.
\end{aligned}
$$

$$
\begin{aligned}
\Leftrightarrow\;& (T+1)Tr^2(1+r)^T(2+\beta-\beta T)-(T+1)\left[2+r(1+T)\right]\cdot\left[\beta rT+(r-\beta)\cdot\left[(1+r)^T-1\right]\right]\\
&\geq Tr^2(1+r)^{T-1}[1+\beta-\beta T]r(1+T)-r(1+T)\left[\beta rT+(r-\beta)[(1+r)^T-1]\right]\\
\Leftrightarrow\;& Tr^2(1+r)^{T-1}(1+\beta-\beta T)+Tr^2(1+r)^T-\left[\beta rT+(r-\beta)[(1+r)^T-1]\right](2+rT)\geq 0\\
\Leftrightarrow\;& Tr^2(1+r)^{T-1}(2+\beta-\beta T+r)-(2+rT)\left[\beta rT+(r-\beta)[(1+r)^T-1]\right]\geq 0. \qquad (40)
\end{aligned}
$$

But (40) is a linear function of β. At $\beta=\frac{r}{1+rT}$, (40) equals

$$\frac{Tr^2(1+r)^T(2+rT)}{(1+rT)}-\frac{Tr^2(1+r)^T(2+rT)}{(1+rT)}=0.$$

At $\beta=0$, the expression in (40) reduces to (after dividing through by r):

$$T\cdot r\cdot(1+r)^{T-1}(2+r)-(2+rT)[-1+(1+r)^T]\geq 0.$$

Letting $s=(1+r)\geq 1$, this inequality holds if and only if

$$T\cdot(s-1)\cdot s^{T-1}\cdot(s+1)-2(s^T-1)-(s^T-1)\cdot T\cdot(s-1)\geq 0,$$

or

$$T\cdot(s-1)(s^{T-1}+1)-2(s^T-1)\geq 0.$$

But this function and its first derivative equal 0 at $s=1$, while the second derivative is

$$(s-1)\cdot T\cdot(T-1)s^{T-3}\cdot(T-2)\geq 0,$$

for all $s\geq 1$. So the function is convex and positive everywhere. Thus (40) ≥ 0 for all $\beta\in[0,\frac{r}{1+rT}]$. We have therefore shown that (39) holds.

We next demonstrate the lower bound inequality:

$$\frac{CC_T(\lambda=-1)-CC_T(\lambda=0)}{CC_T(\lambda=-1)-CC_T(\lambda=\infty)}\geq\frac{2}{3}.$$

Expanding these expressions using (38), we are required to show that

$$\frac{Tr^2(1+r)^{T-1}(1+\beta-\beta T)}{(r-\beta)[(1+r)^T-1]+\beta rT}-\frac{6Tr^2(1+r)^T(2+\beta-\beta T)}{2r(1+T)\left[\beta rT+(r-\beta)[(1+r)^T-1]\right]}+\frac{6}{r(1+T)}+2\geq 0,$$

$$\Leftrightarrow Tr^3(1+r)^{T-1}(1+T)(1+\beta-\beta T)-3Tr^2(1+r)^T(2+\beta-\beta T)+6\big[\beta rT+(r-\beta)[(1+r)^T-1]\big] \\ + 2r(1+T)\big[\beta rT+(r-\beta)[(1+r)^T-1]\big] \geq 0,$$

$$\Leftrightarrow Tr^2(1+r)^{T-1}(1+\beta-\beta T)[r+rT-3(1+r)]-3Tr^2(1+r)^T+2[3+r+rT]\big[\beta rT+(r-\beta)[(1+r)^T-1]\big] \geq 0. \tag{41}$$

Again, this is a linear function of β, so it suffices to show that (41) holds at its end points. At $\beta = \frac{r}{1+rT}$, the expression reduces to

$$Tr^2(1+r)^{T-1}\frac{(1+r)}{(1+rT)}[r(1+T)-3(1+r)] - 3Tr^2(1+r)^T + 2[3+r+rT]\cdot\frac{r^2(1+r)^T T}{(1+rT)}$$
$$=\frac{Tr^2(1+r)^T}{(1+rT)}[r+rT-3-3r+6+2r+2rT] - 3Tr^2(1+r)^T$$
$$=\frac{Tr^2(1+r)^T}{(1+rT)}[3(1+rT)] - 3Tr^2(1+r)^T = 0.$$

At $\beta = 0$, we need to show that

$$Tr^3(1+r)^{T-1}(1+T) - 6Tr^2(1+r)^T + 6r((1+r)^T-1) + 2r^2(1+T)((1+r)^T-1) \geq 0$$

$$\Leftrightarrow T(1+T)s^{T-1}(s^2-2s+1) - 6T(s-1)s^T + 6(s^T-1) + 2(1+T)(s-1)(s^T-1) \geq 0$$

$$\Leftrightarrow T(1+T)s^{T+1} - 2T(1+T)s^T + T(1+T)s^{T-1} - 6Ts^{T+1} + 6Ts^T + 6s^T - 6 \\ + 2(1+T)s^{T+1} - 2(1+T)s^T - 2s(1+T) + 2(1+T) \geq 0$$

$$\Leftrightarrow (T-2)(T-1)s^{T+1} - 2(T-2)(T+1)s^T + T(1+T)s^{T-1} - 2(1+T)s + 2T - 4 \geq 0.$$

Again, this equals 0 at $s = 1$. In addition, its derivative is

$$(T-2)(T-1)(T+1)s^T - 2(T-2)(T+1)Ts^{T-1} + T(1+T)(T-1)s^{T-2} - 2(1+T)$$

$$\propto (T-2)(T-1)s^T - 2(T-2)Ts^{T-1} + T(T-1)s^{T-2} - 2.$$

This equals 0 at $s = 1$. Its derivative in turn is

$$T(T-2)(T-1)s^{T-1} - 2T(T-1)(T-2)s^{T-2} + T(T-1)(T-2)s^{T-3}$$
$$=T(T-1)(T-2)s^{T-3}(s-1)^2 > 0,$$

for all $T > 2$ and all $s > 1$. We have thus established that (41) is strictly positive for values of β between 0 and $\frac{r}{1+rT}$. We conclude that for any level of decay in that range, the ratio bounds of $\frac{2}{3}$ and $\frac{T}{T+1}$ hold. ■

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