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Conservatism, growth, and return on investment

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Abstract Return on Investment (ROI) is widely regarded as a key measure of firm profitability. The accounting literature has long recognized that ROI will generally not reflect economic profitability, as determined by the internal rate of return (IRR) of a firm's investment projects. In particular, it has been noted that accounting conservatism may result in an upward bias of ROI, relative to the underlying IRR. We examine both theoretically and empirically the behavior of ROI as a function of two variables: past growth in new investments and accounting conservatism. Higher growth is shown to result in lower levels of ROI provided the accounting is conservative, while the opposite is generally true for liberal accounting policies. Conversely, more conservative accounting will increase ROI provided growth in new investments has been ''moderate'' over the relevant horizon, while the opposite is true if new investments grew at sufficiently high rates. Taken together, we find that conservatism and growth are ''substitutes'' in their joint impact on ROI.

Keywords Return on investment · Conservatism · Economic profitability

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Introduction

Return on Investment (ROI) is arguably the most prevalent measure of profitability. In financial statement analysis, ROI is a key profitability metric along with the

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Market-to-Book and the Price-Earnings ratios. For management control purposes, firms continue to rely on the ROI metric in order to evaluate the performance of business units that are organized as profit centers and have authority to make investment decisions. In the industrial organization literature, ROI is frequently invoked to gauge the competitiveness of particular industries and to justify antitrust measures.[1] Finally, in many regulated industries, including utilities and telecommunications, product prices have traditionally been set to satisfy the constraint that the regulated firm earns a targeted return on its investments.

The prevalence of the ROI metric appears to be grounded in the notion that, at least under ideal circumstances, this metric can capture economic profitability as represented by the internal rate of return (IRR) of a firm's projects.[2] To that end, the accounting literature has examined neutral (unbiased) accounting rules which have the property that for a given project the resulting ROI is constant over time and, by implication, then equal to the project's IRR; see, for instance, Beaver and Dukes (1974). In contrast, external financial reporting rules (GAAP) are generally not viewed as unbiased but instead as conservative. While the accounting literature has not settled on a single comprehensive definition of conservatism, a common implication of the different notions of conservatism appears to be that on average book values are understated.[3] This tendency suggests that, given conservative accounting, the Return-on-Investment metric will be distorted upward relative to the underlying IRR. Furthermore, it has been shown that such upward distortions may not revert over time, but can persist indefinitely for firms in a steady state.[4]

Our objective in this paper is to examine analytically and empirically how a firm's ROI is impacted by two central variables: accounting conservatism and growth. We address the following three basic questions. First, under what circumstances will ROI exceed economic profitability, as measured by the underlying IRR? Second, what is the impact on ROI if either growth or conservatism changes unilaterally, and how does the directional change depend on the specification of the other variable? Finally, how do these two variables interact, i.e., do they offset or reinforce each other in their impact on ROI? In addressing these three questions, our study builds on earlier partial findings which have examined the behavior of ROI in a variety of theoretical, numerical and empirical contexts.

[1] For instance, Scherer (1982) cites abnormally high ROAs in the breakfast cereal industry as a rationale for why the Federal Trade Commission intervened in that industry. Similarly, in the recent discussion about ''excessive profits'' in the oil refining industry, commentators frequently cite evidence based on ROI data. Some organizations, like the OECD, have also used ROI measures for country-wide comparisons of profitability; see, for instance, Chan-Lee and Sutch (1985).

[2] Earlier studies exploring the connection between IRR and ROI include Solomons (1961), Solomon (1966), Fisher and McGowan (1983), Salamon (1985, 1988), Bar-Yosef and Lustgarten (1994) and Stark (2004).

[3] Feltham and Ohlson (1996), Ohlson and Zhang (1998) and Zhang (2000) refer to accounting as conservative if on average market values exceed book values. In contrast, Basu (1997) and Watts (2003) emphasize asymmetry in the recognition of anticipated losses as opposed to the non-recognition of anticipated gains.

[4] See Zhang (2000, 2001) for several fundamental asymptotic results. Brief (2002), Danielson and Press (2003), Penman (2003, Ch. 16), and Gjesdal (2004) derive steady state characterizations of ROI in finite horizon settings.

Our model views the firm and its financial statements as an aggregate of individual investment projects undertaken at different dates in the past. These investment projects are assumed to have the same underlying economic profitability, i.e., the same IRR.[5] Periodic growth is represented as the rate of change in new investments. In effect, a growing firm effectively conducts the same ''representative'' project, albeit on a larger scale in more recent periods. A major simplification of our model is that growth is treated as an exogenous variable. This assumption seems most plausible in a competitive industry setting, where in equilibrium all firms earn the required cost of capital on their investments, independent of their growth rate. In a competitive industry, aggregate growth in new investment (or decline) will be determined by changes in aggregate demand, yet the growth of individual firms, or the entry of new firms, is essentially indeterminate.[6]

We initially follow earlier literature in calling the accounting *conservative* if investments are written off faster, in a cumulative sense, than they would have been under neutral (unbiased) accounting.[7] Conversely, *liberal* accounting requires new investments to be amortized more slowly in comparison to neutral accounting. These concepts of conservatism give rise to the following fundamental finding, which we refer to as the ''quadrant result'': ROI exceeds the IRR if the accounting is conservative and growth is *moderate* in the sense that new investments grew at a rate less than the IRR in each period over the relevant past. With *aggressive* growth (a rate higher than the IRR), in contrast, ROI is predicted to be below the IRR. Liberal accounting reverses the ordering such that moderate (aggressive) growth results in an ROI lower (higher) than the IRR.[8] For our empirical tests, we accept that U.S. GAAP amounts to conservative accounting, and therefore focus on confirming that ROI, when viewed as a function of growth, will be concentrated in either the North-West or the South-East quadrant. Our logistic regressions support this prediction.

The quadrant result strongly suggests a partial answer to our second question: given conservative accounting, does faster periodic growth in new investments lead to a monotonic decrease in ROI? Such a monotonic relation turns out to be true only if one invokes a stronger notion of conservatism which requires that the recognition of value (viewed in terms of residual income) is delayed not only in a cumulative,

5 This is consistent with the perspective in Penman (2003), Gjesdal (2004) and Richardson et al. (2006).

6 A central question in the industrial organization literature is whether in the long run firm profits tend to revert to competitive levels. To answer this question, a variety of profit measurement methodologies have been developed; see, for instance, Mueller (1986) and Stark (2004). Some authors, including Fisher and McGowan (1983), have argued that it is generally impossible to infer economic profitability from reported accounting rates of return. Our perspective in this paper is to explore how the key variables of growth and conservatism shift the accounting rate of return relative to the underlying economic rate of return.

7 This representation of conservatism is equivalent to the criterion that at each point in time the fair market value of a firm's projects exceeds the book value (Feltham and Ohlson 1996; Zhang 2000). In the language of Beaver and Ryan (2004), we consider unconditional conservatism, in contrast to the conditional, i.e., event-dependent, conservatism of Basu (1997) and others.

8 Fisher and McGowan (1983), Gjesdal (2004) and others have demonstrated special versions of the quadrant result, for instance, by restricting attention to settings where the firm is in a steady state, i.e., investments grow at a constant rate in each period.

second-order sense but in a uniform, first-order sense. For lack of a better term, we refer to this criterion as *neo-conservatism*. This stronger form of conservatism is met, for instance, if straight-line depreciation is applied to projects with uniform cash flows, or if a share of new investments is directly expensed. Given neo-conservatism, it can be shown that higher growth in any past period of the relevant time horizon will ceteris paribus lower current ROI.

Partial expensing of new investments, like those for R&D and other intangible assets under GAAP, is arguably an extreme form of conservatism. More conservative accounting can then be represented by a higher share of directly expensed investments. This notion is closely related to the ''C-Score'' concept of Penman and Zhang (2002). At a general level, the natural question in our analysis is whether, holding growth and other variables fixed, more conservative accounting will result in a higher ROI. Consistent with our earlier classification, this turns out to be true only if growth rates are moderate. For aggressive growth, in contrast, the ''numerator effect'' in the ROI metric tends to dominate. As a consequence, these firms tend to report lower ROI's as their accounting becomes more conservative, possibly because a higher share of their investments is directly expensed.[9]

Our analysis focuses primarily on characterizing ROI at any given date as a function of conservatism and the pattern of growth over the past T years, where T is the useful life of the representative project. Yet, our analysis also generates predictions regarding the change in ROI across consecutive years. In contrast to Fairfield et al. (2003), who test the hypothesis that one-year ahead ROI is decreasing in the growth of current net-operating assets, we predict and empirically confirm that the relevant criterion for changes in one-year ahead ROI is whether the current growth rate exceeds (is below) the average growth rate over the relevant past periods.

With regard to the interaction between growth and conservatism in their joint impact on ROI, we find that these two variables are ''substitutes''. Given conservative accounting, an increase in growth not only tends to lower ROI, but this downward effect is magnified further by more conservative accounting rules. If one represents higher degrees of conservatism by a one-dimensional parameter, such as the rate at which investments are amortized or the share of investments that are expensed directly, the cross-partial derivative of ROI in growth and conservatism is predicted to be negative. Our data analysis supports this negative cross partial interaction. In terms of second-order effects, we also demonstrate analytically, and support empirically, that the reported ROI is a decreasing and convex function of the firm's growth rate.

The remainder of the paper is organized as follows. Section 1 formalizes the elements of our model, including investment projects, growth and conservatism. We then derive a sequence of propositions regarding the joint impact of growth and conservatism on ROI. Several of these predictions lend themselves to empirical tests which are reported in Sect. 2. We conclude in Sect. 3.

[9] These predictions are related to the work of Lev et al. (2005) who examine whether expensing of R&D tends to generate conservative or aggressive performance measures.

1 Theory development

1.1 Transactions and accrual accounting

To capture the impact of growth and conservatism on the accounting rate of return, we consider a firm which in each period has access to a representative investment project with identical characteristics. Growth is represented as intertemporal changes in the scale of the representative project, i.e., changes in investment expenditure. Growth is an exogenous variable in our model. This specification is justified for competitive industries, where in equilibrium all firms earn the required cost of capital on their investments, independent of their growth rate. Aggregate growth (or decline) will be determined by changes in aggregate demand in a competitive industry, yet for an individual firm growth is a matter of indifference.

We denote the representative project by $\mathcal{P} = (b^o, c_1^o, \ldots, c_T^o)$. It involves an initial investment expenditure of b^o, followed by annual cash inflows of c_t^o over the next T periods. There is no sign restriction on the individual c_t^o's, however we postulate that the project's internal rate of return, denoted by r, is unique. Depreciation is the only accrual in our model, with depreciation schedules represented by $\vec{d} = (d_1, \ldots, d_T)$.[10] Assuming comprehensive income measurement, we have $\sum_{t=1}^{T} d_t = 1$, and the income of the representative project in period t is $Inc_t^o = c_t^o - d_t \cdot b^o$, while the date-$t$ book value is given by $BV_t^o = (1 - \sum_{i=1}^{t} d_i) \cdot b^o$.

Since projects have a useful life of T periods, the firm's overall accounting rate of return is essentially a weighted average of the rates of return for the representative project, with the weights determined by the growth rates over the last T periods.[11] This feature reflects that the representative project is ''scalable'' in the sense that any increase in new investment from one year to the next will result in a proportional increase of the associated project cash flows, c_t^o. The growth rate in new investments (and project scale) in year t will be denoted by λ_t. While our model formulation presumes certainty, we note that our results are readily extended to environments in which the project cash flows, c_t^o, are subject to random shocks. Provided new investments and their growth evolve deterministically, the propositions derived in this section would then pertain to the *expected* ROI in any given period.

The firm's overall accounting rate of return at date T is determined jointly by the accounting rules for the representative project and the growth pattern $\vec{\lambda} = (\lambda_1, \ldots, \lambda_{T-1})$ over the past T years:

$$ROI_T(\vec{\lambda}) = \frac{Inc_T(\vec{\lambda})}{BV_{T-1}(\vec{\lambda})} \equiv \frac{Inc_T^o + Inc_{T-1}^o \cdot (1+\lambda_1) + \cdots + Inc_1^o \cdot \prod_{i=1}^{T-1}(1+\lambda_i)}{BV_{T-1}^o + BV_{T-2}^o \cdot (1+\lambda_1) + \cdots + BV_0^o \cdot \prod_{i=1}^{T-1}(1+\lambda_i)}. \tag{1}$$

[10] For ease of notation, we initially do not consider the possibility of immediate (partial) expensing of new investments. Our model is expanded in Sect. 1.4 so as to include this possibility. It is readily checked that the results derived in this subsection and the next are unaffected if one allows for partial expensing.

[11] One can interpret our setting as one where all free cash flows obtained in previous periods were paid out as dividends.

For future reference, we note that in the special case of constant annual growth, i.e., $\lambda_t = \lambda$ for all t, *ROI* remains in a steady state in subsequent periods, that is, $ROI_T(\lambda) = ROI_{T+t}(\lambda)$. To formalize the concept of conservatism, we begin with neutral (unbiased) accounting for the representative project. Following Stauffer (1971) and Beaver and Dukes (1974), a depreciation schedule will be called *neutral* if:

$$\frac{Inc_t^o}{BV_{t-1}^o} = r \tag{2}$$

for all t. It is well known that if one merely requires the ratios $\frac{Inc_t^o}{BV_{t-1}^o}$ to be constant over time, then this constant must equal the project's internal rate of return, r.[12] It is also well-known that for any given cash flow pattern $(b^o, c_1^o, \ldots, c_T^o)$, there exists one, and only one, neutral depreciation schedule. We denote this schedule by $\vec{d}^* = (d_1^*, \ldots, d_T^*)$. For future reference, it will be useful to note that growth has no impact on $ROI_T(\vec{\lambda})$ provided the accounting is neutral. To illustrate, suppose $T = 2$. If both $\frac{Inc_1^o}{BV_0^o}$ and $\frac{Inc_2^o}{BV_1^o}$ are equal to r, then

$$ROI_2(\vec{\lambda}) = \frac{Inc_2^o + Inc_1^o \cdot (1 + \lambda_1)}{BV_1^o + BV_0^o \cdot (1 + \lambda_1)} = r \tag{3}$$

for any λ_1. More generally, it will be useful to think of $ROI_T(\vec{\lambda})$ as a weighted average of the ''component ratios'' $\frac{Inc_t^o}{BV_{t-1}^o}$. For instance, $ROI_2(\vec{\lambda})$ is a weighted average of $\frac{Inc_1^o}{BV_0^o}$ and $\frac{Inc_2^o}{BV_1^o}$, and this average gravitates towards $\frac{Inc_1^o}{BV_0^o}$ as λ_1 gets larger.

Consistent with earlier literature, we initially represent conservatism by the requirement that at each point in time depreciation is accelerated relative to the charges under neutral accounting.

Definition 1 A depreciation schedule $\vec{d} = (d_1, \ldots, d_T)$ is conservative for the investment project $\mathcal{P} = (b^o, c_1^o, \ldots, c_T^o)$ if for all $1 \le t \le T - 1$:

$$\sum_{i=1}^{t} d_i \ge \sum_{i=1}^{t} d_i^*.$$

The accounting will be called *liberal* if the preceding inequality is reversed and therefore the depreciation charges are backloaded relative to the benchmark of neutral accounting. Definition 1 is, of course, equivalent to the condition that the book values, BV_t^o resulting under conservative accounting are always less than they would have been under neutral accounting, i.e., BV_t^{o*}. To operationalize Definition 1 further, it will be useful to look at the evolution of the residual income numbers over time. For the representative project, let $RI_t^o \equiv Inc_t^o - r \cdot BV_{t-1}^o$. Since r is the project's internal rate of return, the present value of the residual income numbers is zero for any depreciation schedule, i.e., $\sum_{i=1}^{T} RI_i^o \cdot \gamma^i = 0$, where $\gamma = \frac{1}{1+r}$.

[12] ROI cannot be either consistently above or consistently below the internal rate of return, for otherwise the present value of the associated residual incomes, with the capital charge rate given by r, could not be zero.

Lemma 1 *The depreciation schedule $\vec{d}$ is* conservative *if and only if:*

$$\sum_{i=1}^{t} RI_i^o \cdot \gamma^i \leq 0$$

for all $1 \leq t \leq T - 1$.[13]

Conservatism therefore requires that the cumulative project value recognized at any point in time is less than the actual project value, which is zero when cash flows (and residual incomes) are discounted at the internal rate of return. For future reference, we note that this criterion amounts to a ''second-order dominance'' condition since it speaks to the cumulative value recognized at any point in time. Earlier literature, including Feltham and Ohlson (1996), Ohlson and Zhang (1998) and Zhang (2000, 2001), has defined conservatism by the criterion that fair market values exceed book values. In our context, the ''fair'' market value of the representative project at date t can be represented by the present value of the remaining cash flows, i.e.,[14]

$$MV_t^o = \sum_{i=t+1}^{T} \gamma^{i-t} \cdot c_i^o.$$

The condition that $MV_t^o/BV_t^o > 1$ for all t is equivalent to the conservatism criterion given in Definition 1 since MV_t^o is equal to BV_t^o plus the sum of future discounted residual incomes, i.e., $MV_t^o = BV_t^o + \sum_{i=t+1}^{T} \gamma^{i-t} \cdot RI_i^o$ (independently of the accounting rules provided income measurement is comprehensive). Because $\sum_{i=1}^{T} RI_i^o \cdot \gamma^i = 0$, we conclude that $MV_t^o > BV_t^o$ if and only if $\sum_{i=1}^{t} RI_i^o \cdot \gamma^i \leq 0$, i.e., the accounting is conservative according to Lemma 1.

1.2 Conservatism and growth

Absent growth, there is a strong intuitive argument as to why conservative accounting results in an abnormally high ROI, relative to the benchmark of the internal rate of return r. Compared to neutral accounting, conservatism depresses all book value terms, other than BV_0^o, in the denominator of (1). At the same time, the ''Canceling Errors'' Theorem ensures that, because there is no growth, aggregate income is unaffected by conservatism (Greenball 1969). Yet, the no growth assumption is clearly important to this conclusion. If growth in each period, λ_t, were precisely equal to r, then irrespective of the accounting rules $ROI_T = r$. To see this, it suffices to multiply the difference $ROI_T(\vec{\lambda}) - r$ by the denominator in (1). If $\lambda_t = r$ for all t, the resulting expression is equal to

$$\gamma^{-T} \cdot \left[\sum_{i=1}^{T} RI_t^o \cdot \gamma^t \right],$$

[13] All proofs are provided in Appendix A.

[14] The word ''fair'' is put in quotation marks here because future cash flows are discounted at the internal rate of return r, rather than some exogenously given cost of capital.

which is indeed equal to zero since the present value of the residual incomes is zero for any depreciation rule. This observation directly suggests that $ROI_T(\vec{\lambda})>r$ if growth is constant and less than r, while the reverse inequality holds if growth is constant and exceeds r. The validity of this claim has been demonstrated by Gjesdal (2004).[15] The following result applies to a larger class of settings where growth may change over time.

Proposition 1 *Conservative accounting implies:*

$$ROI_T(\vec{\lambda})\begin{cases} \geq r & if \quad \lambda_t \leq r \;\; for\,all \;\; 1 \leq t \leq T \\ \leq r & if \quad \lambda_t \geq r \;\; for\,all \;\; 1 \leq t \leq T. \end{cases} \tag{3}$$

Conversely, with liberal accounting, $ROI_T(\vec{\lambda}) \leq r\, if\, \lambda_t \leq r\, for\, all\, 1 \leq t \leq T-1$, *while* $ROI_T(\vec{\lambda}) \geq r\, for\; \lambda_t \geq r, 1 \leq t \leq T-1.$+

We label Proposition 1 the ''quadrant result.'' This label suggests itself in the special case of constant annual growth for the coordinate system shown in Fig. 1 whose axes are λ and ROI_T. The function $ROI_T(\cdot)$ is then always contained in one of the four possible quadrants, depending on (i) whether the accounting is conservative or liberal and (ii) the rate of growth is *moderate*, i.e., $\lambda_t \leq r$, or *aggressive*, i.e., $\lambda_t \geq r$. The proof of Proposition 1 is based on Farkas Lemma (see, for instance, Rockafellar 1970). Since this lemma provides an ''if and only if'' condition, Proposition 1 can also be read in the reverse direction: the inequality $ROI_T(\vec{\lambda}) \geq r$ holds for *all* conservative accounting policies only if growth is moderate. Holding the accounting rules *fixed*, the inequality $ROI_T(\vec{\lambda}) \geq r$ will, of course, obtain for a whole range of growth vectors with annual growth sometimes moderate and sometimes aggressive.

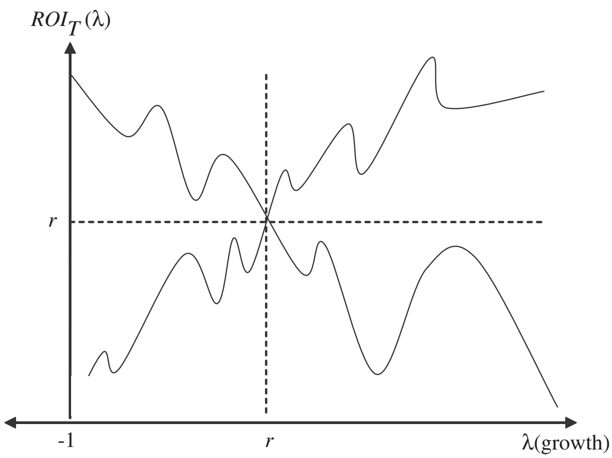

Fig. 1 Illustration of quadrant result

[15] Partial versions of this result have also been demonstrated in Fisher and McGowan (1983) and Danielson and Press (2003).

Since the quadrant result only predicts the magnitude of ROI relative to the economic rate of return, one might conjecture that the assumption of a representative project is actually not crucial. Intuitively, the North-West Quadrant result, for instance, should continue to hold if the ''base'' project (i.e., before growth) available to the firm in period t is $\mathcal{P}^t = (b^o, c_1^t, \ldots, c_T^t)$, such that $\mathcal{P}^t$ has uniformly higher cash flows than $\mathcal{P}$. To extend Proposition 1 in this direction, we require that the accounting be the same for all projects, that is, the choice of depreciation schedule is *time-invariant*. We submit the following finding without proof.

Corollary 1 *Suppose the base project in period t is given by* $\mathcal{P}^t = (b^o, c_1^t, \ldots, c_T^t)$ *such that* $c_i^t \geq c_i^o$ *for all t and i. Then*

$$ROI_T(\vec{\lambda}) \geq r$$

provided the accounting is time-invariant and conservative relative to $\mathcal{P}$, *and* $\lambda_t \leq r$ *for all* $1 \leq t \leq T$.

One illustration of this result is provided by the observation that for financial reporting purposes the overwhelming majority of U.S. firms use straight-line depreciation for plant, property and equipment assets. Such depreciation charges are conservative if the representative project entails uniform cash flows. The North-West Quadrant result therefore remains valid if the actual project cash flows for the base projects $\mathcal{P}^t$ weakly dominate the uniform level given by the representative project, yet straight-line depreciation is applied to all investments. A corresponding extension of Proposition 1 for the South-East quadrant is obtained provided $c_i^t \leq c_i^o$.

Proposition 1 shows that the accounting rate of return will always match the economic rate of return, r, in either one of two settings: (i) accounting is neutral or (ii) growth in each period is equal to r. A direct comparison of neutral and conservative accounting in Fig. 1 suggests that more conservative accounting will tend to increase ROI_T provided growth is moderate, while the opposite is true when growth has been aggressive in the past. To formalize this intuition, we define the depreciation schedule $\vec{d} + \vec{u}$ to be *more conservative* than $\vec{d}$ if $\sum_{i=1}^{t} u_i \geq 0$ for all $1 \leq t \leq T - 1$.

Proposition 2 *More conservative accounting increases* ROI_T *provided* $\lambda_t \leq r$ *for all* $1 \leq t \leq T - 1$. *Conversely, more conservative accounting decreases* ROI_T *whenever* $\lambda_t \geq r$ *for all* $1 \leq t \leq T - 1$.

Proposition 2 is illustrated in Fig. 2. For simplicity, growth rates are again held constant, i.e., $\lambda_t = \lambda$ for all t. The dashed line, corresponding to more conservative accounting, crosses the solid $ROI_T(\cdot)$ function, corresponding to less conservative accounting, only once at the point where the periodic growth rate λ is equal to r. Thus we obtain a ''single-crossing'' property, with more conservatism accounting rotating the *ROI* function in a ''clockwise'' fashion around the Pivot Point $(\lambda, ROI_T(\lambda)) = (r, r)$.

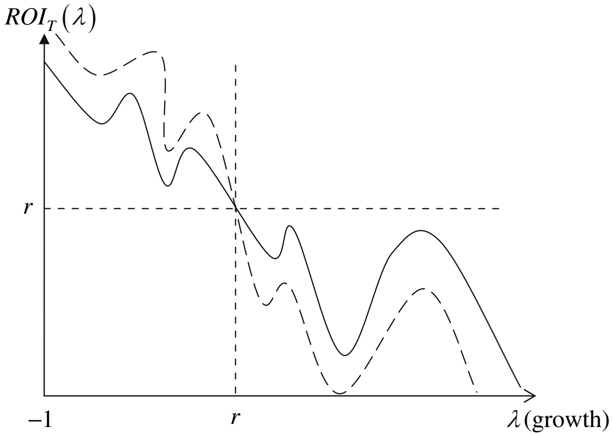

Fig. 2 Effect of more conservative accounting

We next turn to the question of how ROI is affected by higher growth rates, holding the accrual accounting rules fixed. One implication of the quadrant result is that if the growth rates are constant over time (i.e., $\lambda_t = \lambda$) and the common growth rate is close to r, then $ROI_T(\vec{\lambda})$ must be decreasing in λ, given conservative accounting. This local monotonicity property turns out not to hold globally under the assumptions made so far. Suppose, for instance, that project cash flows are distributed uniformly. If $r = .18$ and $T = 3$, the depreciation schedule $(d_1 = .45, d_2 = .18, d_3 = .37)$ is conservative, yet ROI_3 is increasing in λ for a range of growth rates $-1<\lambda<0$.[16] However, in this example the residual income numbers, RI^o_t, for the representative project are non-monotonic over time. In particular, RI^o_2 is the largest of the three values owing to the small depreciation charge in period 2. This observation motivates the following stronger notion of conservatism, which, for a lack of a better term, we refer to as ''neo-conservatism.''

Definition 2 A depreciation schedule $\vec{d} = (d_1, \ldots, d_T)$ is neo-conservative for the investment project $\mathcal{P} = (b^o, c^o_1, \ldots, c^o_T)$ if the sequence $RI^o{}_t$ is monotone increasing in t.

In contrast to the condition posited in Definition 1 (or equivalently in Lemma 1), the monotonicity requirement in Definition 2 says that the residual income sequence starts out negative and increases monotonically to positive levels. In that sense, neo-conservatism also says that the value of the representative project is recognized with delay. However, the delay in value recognition must not merely hold in a cumulative (second order) sense but in a uniform (first order) sense: up to some critical date $\hat{t}$, with $1<\hat{t}<T$, too little value is recognized, while too much is

[16] Gjesdal (2004) also notes that even with constant growth $ROI_T(\lambda)$ may not be a decreasing function of λ.

recognized thereafter.[17] It seems natural to define one depreciation schedule as more neo-conservative than another provided the corresponding residual income sequences, viewed as functions of time, intersect only once, such that the more conservative schedule has lower *RI* values in earlier periods.

For future reference, we note that in the special case of uniformly distributed cash flows, straight line depreciation leads to linearly increasing residual incomes and therefore such accounting is neo-conservative. This observation does not contradict Penman's (2003, Chapter 16) examples where straight-line depreciation reflects neutral accounting, because in these examples cash flows are not uniform but decreasing over time. It is also worth noting that if a depreciation schedule satisfies neo-conservatism relative to some capital charge rate $\hat{r}$ in the calculation of residual income, the required monotonicity will also hold for any capital charge rate r greater than $\hat{r}$.[18]

Proposition 3 *Given neo-conservative accounting,* $ROI_T(\vec{\lambda})$ *is decreasing in each* λ_t.

Absent growth, ROI_T is a weighted average of the individual $\frac{Inc_t^o}{BV_{t-1}^o}$, representing the *ROI* of different vintages of investments over the past T years. Neo-conservatism implies that the sequence $\frac{Inc_t^o}{BV_{t-1}^o}$ is increasing in t (though the reverse is not true). Therefore older vintage projects contribute an *ROI* that exceeds r, while new projects do the opposite. Note that these distortions do not average out because the identity

$$\sum_{t=1}^{T}\left(\frac{Inc_t^o}{BV_{t-1}^o}-r\right)\cdot BV_{t-1}^o\cdot\gamma^t=\sum_{t=1}^{T}RI_t^o\cdot\gamma^t=0$$

shows that the upward distortion of $\frac{Inc_t^o}{BV_{t-1}^o}$ relative to r must, in comparison, be much larger for older vintage investments than the downward distortion (relative to r) for new investments. For that reason, neo-conservatism implies that $ROI_T > r$ in the absence of growth. As growth increases in any given year i, there will be an even greater weight attached to the lower $\frac{Inc_t^o}{BV_{t-1}^o}$ corresponding to new investments in all periods $t > i$.

[17] If one imposes the stronger condition of neo-conservatism and assumes that annual growth is constant, i.e., $\lambda = \lambda_t$, then the ''quadrant'' result of Proposition 1 follows from the following simple argument: $ROI_T(\lambda) \geq r$ is equivalent to $\sum_{t=1}^{T} RI_t^o \cdot (1+\lambda)^{T-t} \geq 0$. We know that this inequality holds as an equality at $\lambda = r$. If the sequence RI_t^o is monotone increasing, it will change sign once and therefore Descartes' ''rule of signs'' yields the conclusion.

[18] In the literature on managerial performance evaluation, Rogerson (1997) and others have advocated the so-called relative benefit depreciation rule as a means of creating goal congruence between owners and managers. As observed in Reichelstein (1997) and Dutta and Reichelstein (2005), relative benefit depreciation amounts to conservative accounting. It is essential to recall, however, that in these models the IRR of the project is unknown to the designer of the residual income performance measure. Instead the designer seeks to motivate the better informed manager to accept those projects for which IRR exceeds the owner's cost of capital, r_c. As a consequence, it is generally impossible to attain neutral accounting. However, for zero-NPV projects, i.e., when $r = r_c$, relative benefit depreciation does indeed result in neutral accounting. In these models, conservatism therefore does not result from an inherent conservatism bias in the depreciation schedule but from information asymmetry about the underlying project profitability.

Earlier empirical literature has been concerned with changes in one-year ahead ROI, that is, the difference $\Delta ROI_T = ROI_{T+1} - ROI_T$. As observed above, if growth rates have been constant over the past T years, say $\vec{\lambda} = (\lambda, \ldots, \lambda)$, ROI will reach a steady state provided growth continues at the same level. However, if growth at date T drops off, i.e., $\lambda_T < \lambda$ and the accounting is neo-conservative, then ROI_{T+1} will exceed ROI_T. The property of neo-conservatism (rather than mere conservatism) is essential here since the smallest component ratio in ROI_{T+1}, i.e., $\frac{Inc_1^o}{BV_0^o}$, will now receive a comparatively small weight owing to the smaller growth rate λ_T.[19] The reverse conclusion is obtained when current growth accelerates relative to past levels. We state this formally below, without proof.

Corollary 2 *Given neo-conservative accounting,* $ROI_{T+1}(\vec{\lambda}, \lambda_T) - ROI_T(\vec{\lambda}) \geq 0$ *if and only if* $\lambda_T \leq \lambda$.

Fairfield, Yohn and Whisenant (2003) formulate and test the hypothesis that changes in one-year ahead ROI is decreasing in current growth of net-operating assets. In contrast, we predict, and support in Sect. 2 below, that one-year ahead ROI exceeds (is below) current ROI if the current growth rate is below (exceeds) the average growth rate over the past T periods.

1.3 Constant growth

The natural question at this point is how growth and conservatism interact in their impact on ROI_T. To that end, we now confine attention to settings in which new investments have grown at a constant growth rate, λ, over the prior T periods. As mentioned above, much of the prior work in accounting and economics on ROI has focused on constant growth settings. In particular, it has been observed that the assumption of constant growth results in a linear (affine) relationship between ROI and the aggregate ‘‘market-to-book’’ ratio. To that end, we denote by $MV_{T-1}(\lambda, r)$ the ‘‘fair’’ market value of past investments, that is, $MV_{T-1}(\lambda, r) \equiv MV_{T-1}^o + MV_{T-2}^o \cdot (1+\lambda) + \cdots + MV_0^o \cdot (1+\lambda)^{T-1}$, where, as defined above, $MV_t^o = \sum_{i=t+1}^{T} \gamma^{i-t} \cdot c_i^o$. By definition, neutral accounting implies $MV_{T-1}(\lambda, r) = BV_{T-1}(\lambda)$.

Proposition 4 *With a constant growth rate,* λ,

$$ROI_T(\lambda) = \lambda + (r - \lambda) \cdot \frac{MV_{T-1}(\lambda, r)}{BV_{T-1}(\lambda)}. \tag{4}$$

Equation (4) immediately recovers the earlier quadrant result for the special case of constant growth rates.[20] Equation (4) also recovers our finding in Proposition 2

[19] Penman (2003) refers to the release of ‘‘hidden reserves’’ as growth slows.

[20] Variants of this equation can be found in Skogsvik (1998) and Danielson and Press (2003). The latter authors also claim (on p. 510) that the derivative of $ROI_T(\lambda)$ with respect to λ is given by $1 - \frac{MV_{T-1}}{BV_{T-1}}$. We contend that this is not true, as the ratio $\frac{MV_{T-1}}{BV_{T-1}}$ itself is generally a function of the growth rate λ. In a different setting, Ohlson and Gao (2006) also derive Eq. (4) under the assumption that future abnormal (residual) earnings grow at a constant rate.

for constant growth settings: the ''market-to-book'' ratio $\frac{MV_{T-1}(\lambda,r)}{BV_{T-1}(\lambda)}$ increases for more conservative accounting policies and therefore $ROI_T^o(\lambda)$ will ceteris paribus increase with a greater degree of conservatism if and only if $\lambda < r$.

One might suspect that growth and conservatism are in fact substitutes in the sense that the decline in ROI due to higher growth rates will be more pronounced for more conservative accounting rules. To that end, suppose that varying degrees of conservatism are represented by a one-dimensional family of depreciation schedules $\vec{d}(\delta)$, such that higher values of δ represent more conservative accounting. Formally, growth and conservatism are said to be substitutes if the function $ROI_T(\lambda,\delta)$ exhibits decreasing differences in λ and δ, that is, the difference $ROI_T(\lambda+\Delta,\delta) - ROI_T(\lambda,\delta)$ is decreasing in δ for any given λ and $\Delta \geq 0$. In light of Proposition 2, decreasing differences amount to the requirement that the difference $ROI_T(\lambda,\delta+\Delta) - ROI_T(\lambda,\delta)$ will widen, in absolute terms, the further away the growth rate is from r. However, it can be shown via examples that the property of decreasing differences does not hold at the current level of generality, which leads us to impose additional structure on the model.

1.4 Uniform project cash flows and geometric depreciation

In addition to constant growth, we now assume that the cash flows associated with the representative project are uniform over T periods. This specification may correspond to a setting in which new investments create fixed production capacity over T periods such that the corresponding ''widgets'' are sold at constant prices (on average) over the next T periods. In addition, we now confine attention to the class of *geometric* depreciation schedules, which have the property that the depreciation charges decline (or grow) geometrically: $d_t = (1-\delta)\cdot d_{t-1}$, or equivalently $d_t = (1-\delta)^{t-1}\cdot d_1(\delta)$. Of course, $d_1(\delta)$ is set by the requirement that the sum of the d_t's be equal to one. Higher values of δ then correspond to more conservative accounting.

It is well known that if project cash flows are uniform over time, neutral accounting corresponds to the annuity depreciation method, i.e., $\delta = -r$. The accounting is conservative, and in fact neo-conservative, for any $\delta > -r$. In particular, straight line depreciation ($\delta = 0$) and the most conservative policy of full expensing in period 1 ($\delta = 1$) fall into this range.[21] Conversely, one obtains increasingly liberal policies by letting δ assume large negative values, resulting in backloaded depreciation charges. Restricting the parameter δ to satisfy $\delta < 1$, the function $ROI_T(\lambda, \delta)$ then becomes:

$$ROI_T(\lambda,\delta) = \lambda + (r-\lambda)\cdot\frac{H(\lambda,r)}{H(\lambda,-\delta)}, \tag{5}$$

where $H(s,z) \equiv \frac{h(s)-h(z)}{s-z}$ and $h(s) \equiv s\cdot\left[1-(1+s)^{-T}\right]^{-1}$ for $s > -1$. Thus the ''market-to-book'' ratio on the right hand side of (4) can now be expressed in terms of the simple function $h(\cdot)$. We note that, by definition, $h(s)$ is the dollar amount

[21] When $T = \infty$, one obtains the familiar declining balance method, provided $0 < \delta < 1$ and $d_t = \delta\cdot AV_{t-1}^o$. As observed in Beaver and Dukes (1974), such a depreciation policy results in neutral accounting if $c_t = (1-\delta)\cdot c_{t-1}$.

which when paid as an annuity over T years has present value of precisely one dollar, given the discount rate s. As a consequence, $\lim_{s\to-1} h(s) = 0, h(0) = \frac{1}{T}$, and $h(s) > 0$ for all values of $s > -1$. We note that $h(\cdot)$ is strictly increasing in s. Two other important properties of this function are stated in the following result.

Lemma 2 *For all values of $s > -1$, $h(s)$ is strictly convex in s and $\frac{h''(s)}{h'(s)}$ is decreasing in s.*

Straightforward algebra shows that the expression for $ROI_T(\lambda,\delta)$ in (5) is symmetric in its two variables: for any $\lambda > -1$, $\delta < 1$, $ROI_T(\lambda, \delta) \equiv ROI_T(-\delta, -\lambda)$. This observation yields a partial converse to Proposition 3: given *liberal* accounting, ROI_T is increasing in the growth rate λ. Despite the additional structure imposed in this subsection, it can be verified that $ROI_T(\lambda,\delta)$ still does not exhibit decreasing differences in growth and conservatism.[22] Importantly, however, this property does hold for the range of all conservative accounting policies, i.e., growth and accounting policy are substitutes when accounting is conservative.

Proposition 5 *Suppose constant growth, uniform project cash flows and geometric depreciation. Given conservative accounting, i.e., $\delta > -r$, the function $ROI_T(\cdot\ ,\cdot)$:*

(i) *is a decreasing and convex function of λ,*
(ii) *exhibits decreasing differences in λ and δ.*

Since the *ROI* function is (negatively) symmetric in growth and conservatism, Proposition 5 implies that $ROI_T(\cdot,\delta)$ is increasing and concave in λ whenever the accounting is liberal. In addition, we conclude that *ROI* is increasing and convex in δ when growth is moderate (i.e., for $\lambda < r$), but decreasing and concave in δ for aggressive growth levels higher than r.[23]

Figure 3 provides a 3-dimensional illustration of the ROI_T function using parameters $T = 3$ and $r = 0.2$. Neutral depreciation is given by $\delta = -0.2$ and *ROI* is accordingly constant at 0.2 in that case. For conservative accounting, represented by $\delta > -0.2$, it is clear that ROI_T is decreasing and convex in λ, while for liberal accounting ($\delta < -0.2$), ROI_T is increasing and concave in λ. To see the collateral changes in ROI_T as a function of δ that arise from the function's negative symmetry, it is helpful to note that the z-axis in Fig. 3 is reversed. The impact of increases in conservatism on *ROI* are then evident from tracing the motion of the ROI_T function from the back to the front of the chart box.

From an institutional and empirical perspective, the most relevant scenario arguably is one where some fraction of new investments is depreciated according to

[22] As a counterexample, consider $T = 5$ and $r = 0.1$. For two liberal depreciation policies, $\delta = -5$ and $\delta = -4.95$, it is easily seen via numerical computation that $ROI_T(\lambda, -5) - ROI_T(\lambda, -4.95)$ is not a monotone function of λ. It crosses 0 from below at $\lambda = r = 0.1$, increases until $\lambda = 1.0343$, and decreases thereafter.

[23] Also, for any given λ and δ, the formulation in (5) and the above mentioned properties of $h(\cdot)$ imply that $ROI_T(\lambda,\delta)$ is always increasing and convex in the internal rate of return r. Thus, regardless of the accounting policy, the choice of more profitable projects always leads to higher accounting rates of return, and does so at an increasing rate.

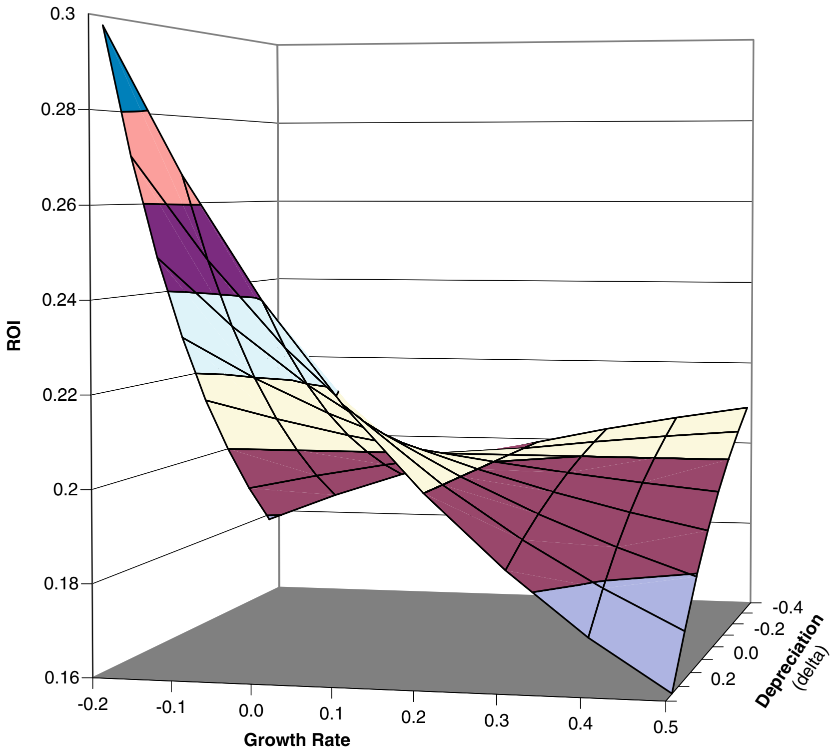

Fig. 3 Return on Investment as a function of depreciation policy and growth in investment

the straight-line method (δ = 0) over the T-period useful life, e.g., tangible fixed assets, and the remainder is expensed immediately, e.g., intangible assets like R&D or Advertising. Ignoring first the possibility of direct expensing, we obtain the following closed form expression for ROI_T under straight-line depreciation:

$$ROI_T(\lambda, 0) = \lambda \cdot \frac{[h(r) - \frac{1}{T}]}{[h(\lambda) - \frac{1}{T}]}. \tag{6}$$

Since, as noted above, the present value of an annuity of $h(s)$ dollars paid over T years at the discount rate s is one dollar, both the numerator and the denominator in the above expression are positive provided $\lambda > 0$. Beyond the monotonicity and curvature results established in Propositions 3 and 5, respectively, we can now provide upper and lower bounds for the range of ROI values.

Corollary 3 *With straight-line depreciation,* $ROI_T(\lambda,0)$ *has the following limits*:

(i) $\lim_{\lambda \to -1} ROI_T(\lambda, 0) = T \cdot [h(r) - \frac{1}{T}]$;
(ii) $\lim_{\lambda \to 0} ROI_T(\lambda, 0) = \frac{2 \cdot T}{T+1} \cdot [h(r) - \frac{1}{T}]$;
(iii) $\lim_{\lambda \to \infty} ROI_T(\lambda, 0) = [h(r) - \frac{1}{T}]$.

Intuitively, the degree of conservatism corresponding to straight line depreciation is increasing in T since for longer lived assets the difference between straight line and annuity depreciation becomes more pronounced. Corollary 3 shows that for rapidly declining firms, $[T \cdot h(r) - 1]$ is an upper bound for ROI_T. Conversely, ROI_T does not tend to zero for rapidly growing firms but is bounded below by $[h(r) - \frac{1}{T}]$. The convexity of ROI in λ is well illustrated by the fact that ROI is cut by a factor of $\frac{2}{T+1}$ as λ goes from negative one to zero, but is cut only by approximately one half as λ goes from zero to infinity.[24]

To introduce varying degrees of conservatism into this setting, we finally allow for a share of new investments to be expensed immediately. In our empirical tests, this share of new investments corresponds to expenditures for R&D and advertising. We therefore maintain the analytic convenience of straight line depreciation for capitalized investments, yet capture the notion of more conservative accounting by a higher fraction of investments that are directly expensed.[25] We represent that fraction by $\beta \in [0,1)$ and use the notation $ROI_T(\lambda, 0, \beta)$ with $ROI_T(\lambda, 0, \beta = 0) \equiv ROI_T(\lambda, 0)$.[26]

Proposition 6

$$ROI_T(\lambda, 0, \beta) = \frac{1}{1-\beta} \cdot [ROI_T(\lambda, 0) - \lambda \cdot \beta] \qquad (7)$$

and $ROI_T(\lambda,0,\beta)$ exhibits decreasing differences in λ and β.

As one would expect, direct write-offs of new investments behave qualitatively like more accelerated depreciation schedules, i.e., higher values of δ, in the above analysis. Figure 4 illustrates that in predicting the impact of partial expensing on ROI the constant growth rate $\lambda = r$ serves as a ‘‘bifurcation’’ point. When periodic growth is less than r, $ROI_T(\lambda,0,\beta)$ is increasing and convex in β, and is unbounded as β approaches one. On the other hand, for $\lambda > r$, $ROI_T(\lambda,0,\beta)$ is decreasing and concave in β, and approaches minus infinity as β approaches one. Specifically, for a firm with $\lambda = -.05$, $r = .15$ and $T = 15$, ROI_T increases from 0.22 to 0.36 to 0.49 as a consequence of increasing the fraction of new investments written off from 0 to one-third to one-half. These points are displayed on the upper curve in Fig. 4. The

[24] We have thus far not commented on the behavior of ROI in T, the useful life of the assets. Under straight line depreciation, we find that for $\lambda > 0$, $ROI_T(\lambda,0)$ is a non-monotonic function of T for $\lambda \neq r$. In particular, $\lim_{T\to 1} ROI_T(\lambda, 0) = \lim_{T\to\infty} ROI_T(\lambda, 0) = r$ and the function $ROI_T(\lambda,0)$ increases (decreases) in T at values of T close to 1 depending on whether $\lambda < (>) r$. A demonstration of these claims is available upon request.

[25] This specification is consistent with the numerical examples in Penman (2003) and Richardson et al. (2006).

[26] Extending Definition 1, the accounting is said to be conservative if $\sum_{i=1}^{t} d_i + \beta \geq \sum_{i=1}^{t} d_i^*$, where $\sum_{i=1}^{T} d_i \equiv 1 - \beta$. Lemma 1 then extends so that conservatism is equivalent to: $-\beta \cdot b^o + \sum_{i=1}^{t} RI_i^o \cdot \gamma^i \leq 0$ for all t. For any $\beta \geq 0$, the criterion for neo-conservatism is unchanged from that in Definition 2, i.e., the sequence of residual income numbers is required to be increasing over time. Neo-conservatism then implies conservatism for any given $\beta \geq 0$. Also, with uniform cash flows, any combination of partial expensing and straight line depreciation for the capitalized part of the investment amounts to neo-conservative accounting.

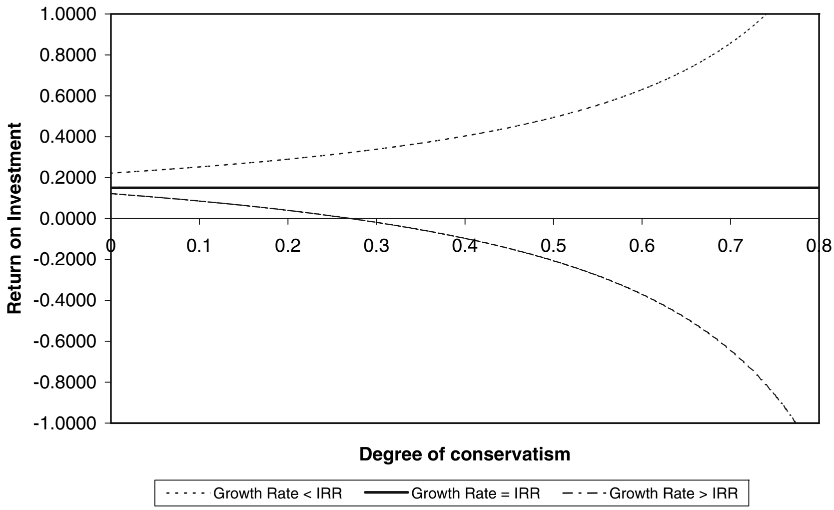

Fig. 4 Impact of conservatism on ROI for varying levels of growth

lower curve in Fig.4, which corresponds to a value of $\lambda = 0.45$, illustrates the $\lambda > r$ scenario.

2 Empirical analysis

A natural question to ask of the preceding model is whether its predictions are consistent with observed accounting data. Our model does not make predictions about the economic behavior of agents. Instead it describes the relation between a firm's operations and the resulting earnings and asset values. At some level, these relations can be viewed as mechanical properties of accounting. However, we recall that our theory development has relied on a number of restrictive assumptions including (i) a representative investment project, (ii) a constant internal rate of return, unaffected by the rate at which the firm's investments have been growing, and (iii) the lack of financing activities. In addition, some of the constructs in our model, such as the internal rate of return of investment projects, useful life, degree of conservatism and cost of capital are either not observable or, at the very least, difficult to measure. The intrinsic limitations of the model combined with the need for empirical proxies therefore make it a meaningful exercise to see if our analytical predictions are consistent with actual patterns of accounting data.

Our empirical tests examine the impact of conservatism and past growth on current return on investment, using a cross-section of firms. These tests speak directly to the three basic questions posed in the first half of the paper. When will ROI exceed (fall below) IRR, what is the impact on ROE if either growth or conservatism change unilaterally and, finally, how do these two variables interact? Nonetheless, we do not view the empirical analysis in this paper as a direct test of the preceding model but rather as a test of the predictions generated by the model.

To illustrate, we find empirical support for the prediction that current ROE is a decreasing function of past investment growth. This finding may reflect that, as posited in our model, firms with higher growth rates maintain the same IRR, which would approximate the cost of capital in a competitive industry. Alternatively, our empirical findings are also consistent with a pattern of decreasing economic profitability (IRR) for firms whose investments have grown at higher rates. The latter pattern would be plausible for firms with significant market power.

It should also be noted that other recent empirical work on conservatism has principally relied on market-price based proxies for both growth and conservatism. For instance, Basu (1997) uses market prices to infer the degree of conservatism. Similarly, the Market-to-Book ratio has been used as both a measure of conservatism and (future) growth prospects. By contrast, our measures of conservatism and growth are based directly on our analytical constructs of β and λ, thereby mirroring our theoretical analysis which does not rely on market valuations. Therefore our approach is not subject to the endogeneity that results when equity prices are used to construct measures of conservatism (Beatty 2006). The remainder of this section proceeds as follows: Sect. 2.1 discusses our empirical proxies for the theoretical constructs, Sect. 2.2 describes sample selection, and finally Sect. 2.3 presents the empirical methodology and the results.

2.1 Empirical proxies

2.1.1 Return on investment

Throughout the model, ROI is used to denote the return to the aggregate of individual investment projects undertaken at different dates in the past. For our empirical analysis, we choose return on equity, ROE, as our primary proxy for ROI. ROE is calculated as operating income after depreciation and after interest expense and interest income (Compustat Item #170) deflated by lagged book value of equity (Compustat Item #60). Because taxes are a relevant aspect of the analysis, we multiply our income measures by (1-marginal tax rate) where the tax rates are the same ones used by Nissim and Penman (2001). As a robustness check, we also re-estimate all of our regressions and empirical tests on a pre-tax basis to maintain consistency between our analysis and other papers in the empirical literature. Inferences are unchanged.[27]

In addition to ROE, we also proxy for ROI using ROA and RNOA in all of our parametric tests. ROA is calculated as operating income before interest (Compustat Item #178) deflated by lagged total assets (Compustat Item #6). Similarly, RNOA is

[27] Since our model presumed that free cash flows are paid out as dividends, it is natural to ask whether the ROE metric is affected by different dividend policies. As a ''first-order'' effect, we note that ROE_t is invariant to a change in dividend payments at date $t-1$ provided the following holds: ROE_t is (initially) equal to the rate of return, r and a dividend payment of Div_{t-1} has the following two effects: BVE_{t-1} is reduced by Div_{t-1}, and at the same time income, Inc_t, is reduces by $r \cdot Div_{t-1}$.

calculated as operating income (Compustat Item #178) deflated by lagged NOA.[28] All the results using ROA and RNOA are discussed in Sect. 2.3.

2.1.2 Useful life

Denoted as T throughout the model, useful life (*Uselife*, hereafter) is the number of periods for which a given investment continues to produce cash flows for the firm. Empirically, there is no such mandated disclosure by management. Additionally, there is the complication that different assets have different useful lives depending on the type of asset and the circumstances surrounding their use in a particular firm. To measure *Uselife*, we simply divide the Gross amount of PPE at the firm (Compustat item #7) by depreciation expense (Compustat item #125) in the current year. Although admittedly rough, this measure represents an estimate of the weighted average useful life of all the capitalized assets in the firm. Note that this measure does not include investments that GAAP mandates be immediately expensed such as R&D and advertising expense.[29]

2.1.3 Average growth in past investments

To represent past growth, i.e., $\vec{\lambda}$ in the model, we will consider the geometric mean $\mu(\vec{\lambda})$ of the growth history of $\vec{\lambda} = (\lambda_1, \ldots, \lambda_{T-1})$. To empirically estimate this construct (*PGrowth*), we calculate the geometric mean of growth in investments over the previous T periods starting in period $t-T+1$.[30] Total investments are calculated as R&D Exp (Compustat item #45) + Advertising expenses (Compustat item #46) + Capital Expenditures (Compustat item #30). Growth in this variable is calculated as [($Total\ Investments_t$ / $Total\ Investments_{t-1}$) − 1]. Unlike *PGrowth*, which measures past growth, $Growth_t$ is growth in investments in the current period.

2.1.4 Degree of conservatism

Assuming straight-line depreciation for capitalized investments, Proposition 6 represents the degree of conservatism, β, as the fraction of investment that is immediately expensed. In the interest of remaining as consistent with the theory as possible, we employ a measure of conservatism (*Conserv*) that divides the portion of

[28] Net Operating Assets (NOA) is calculated as $Operating\ Assets_t - Operating\ Liabilities_t$. Operating Assets is total assets less cash and short-term investments (Compustat item #1 and item #32). Operating liabilities is total assets less the long and short-term portions of debt (Compustat items #9 and #34), less book value of total common and preferred equity (Compustat items #60 and #130), less minority interest (Compustat item #38).

[29] Implicitly, we assume that the useful life of these assets is not significantly different than the average life of the capitalized assets.

[30] Note that the current year will be referred to as t in the empirical analysis, whereas T denotes the useful life of the assets (as discussed above).

investment immediately expensed by total investments [(R&D Exp + Adv Exp)/(R&D Exp + Adv Exp + Capitalized Expenditures)].[31]

We acknowledge several alternative measures of conservatism that have been considered in the empirical accounting literature, including Basu (1997), Givoly and Hayn (2000), Penman and Zhang (2002), Beaver and Ryan (2004), Ball and Shivakumar (2005) and Monahan (2005).[32] However, our measure reflects our construct of β and thereby conforms to our theory framework. It has the added benefit of focusing on past transactions without the interference of future expectations embedded in the measure. Finally, β is easy to calculate for a given firm-year. In contrast, the measures by Basu (1997) and Ball and Shivakumar (2005), for example, are derived from a coefficient in a cross-sectional regression.

2.1.5 Cost of capital and internal rate of return

Our theoretical analysis has treated the internal rate of return (r) as exogenous, with the sole restriction that it at least equals the required rate of return r_c. From an empirical standpoint it is exceedingly difficult to capture the internal rate of return for individual firms at particular points in time. This motivates us to decompose r into two, more easily measured concepts. In particular, we decompose the internal rate of return into the cost of capital, on the one hand, and into ''abnormal'' profitability, on the other hand. To do this decomposition in a manner that is fully consistent with our prior analysis, we suppose that economic profitability is captured by a variable θ that scales the firm's (constant) cash flows from any investment. In other words, given the internal rate of return r, the following zero-NPV condition holds:

$$\frac{c^o \cdot \theta \cdot [1-(1+r)^{-T}]}{r} - b^o = 0, \tag{8}$$

where $\theta \geq 1$ represents the abnormal profitability parameter. A value of $\theta = 1$ corresponds to a competitive industry where all investments yield zero NPV relative to the required cost of capital $r = r_c$. Thus, (8) holds at $\theta = 1$ provided r is replaced by $r = r_c$, while higher values of θ correspond to an internal rate of return in excess of r_c. For our setting in Proposition 5, ROI can now be represented as:

$$ROI_T(\lambda, 0, \beta | r_c, \theta) = \frac{1}{1-\beta} \cdot [ROI_T(\lambda, 0 | r_c, \theta) - \lambda \cdot \beta],$$

where

[31] It could be argued that this measure simply measures the degree to which a firm belongs to an industry that employs a great deal of ''intangible assets,'' e.g., the pharmaceutical industry. We accept this criticism, but argue that this strong correlation with industry does not diminish the measure's usefulness since these industries are ones in which there is a higher degree of conservatism. Note that our theory does not require that the degree of conservatism be relative to firms within the industry but rather across the economy.

[32] Among the many proxies for conservatism that have been employed in the literature, the one that is closest in spirit to ours is the ''C-score'' of Penman and Zhang (2002). Their metric captures conservatism as a notion of reserve creation; it uses R&D expense, advertising expense and LIFO reserves and compares them to *NOA* to obtain a measure of the ''quality'' of earnings.

$$ROI_T(\lambda, 0|r_c, \theta) = \lambda \cdot \frac{[h(r_c) \cdot \theta - \frac{1}{T}]}{[h(\lambda) - \frac{1}{T}]}. \qquad (9)$$

Thus we have replaced the internal rate of return by two other constructs: the required rate of return, r_c, and the firm's level of abnormal profitability, θ.

Measuring the firm's cost of capital has proven difficult at best. Some in finance have used the three-factor model (Fama and French 1993). However, Fama and French (1995) argue that the cost of capital estimates that emerge from this model are imprecise at both the firm and industry level ultimately concluding this method involves a 'wing and a prayer.' Over the past few years, accounting researchers have developed a variety of alternative techniques to determine the cost of capital generally relying on the assumption of a valuation model with discounted cash flows. These measures do not come without controversy. Easton and Monahan (2005) review seven accounting-based proxies for the cost of capital. Their results suggest that none of these proxies are reliable and do not have positive associations with realized returns. However, they find that some proxies are reliable when long-term growth forecasts are low (Easton et al. 2002). Using a different methodology, Botosan and Plumlee (2005) review five empirical proxies from the literature and evaluate them for consistency and relation to risk. They find that two of them, the r_{DIV} (Botosan and Plumlee 2002) and r_{PEG} (Easton 2004), dominate the other alternatives. Others, using different methodologies, come to somewhat different conclusions. For example, Guay et al. (2005) find that r_{GLS} (Gebhardt et al. 2001) is the best predictor of future realized returns. Appendix B provided a summary of these three measures.[33]

Because each of the above methods requires data from different sources, choosing one particular method may limit the number of observations and possibly bias our sample depending on the data that is required for the respective measure. Accordingly, we use an arithmetic average of these three measures as our empirical proxy for the cost of capital.[34] Since each of the three measures may have a different

[33] Although our analysis does not seek to reconcile the differences between these cost-of-capital studies, we note several points made in earlier work. Botosan and Plumlee (2005) argue that the Vuolteenaho (2002) linear decomposition approach used by Easton and Monahan (2005) may not be properly specified because of the negative relation between EM's ''preferred'' metric and risk, as measured by beta or the standard deviation of returns. In contrast, Guay et al. (2005) argue that the lack of reliability of the expected return proxies in Easton and Monahan's study warrants a different approach. Easton and Monahan (2005) argue that neither of these two studies properly deals with the assumption that realized returns are biased and noisy measures of expected returns. Note that all of these studies examine COC measures in the cross-section. In the finance literature, Pastor et al. (2006) estimate the time-series relation between market-level measures of COC and market risk analytically (using simulations) and empirically. They argue that these same measures are a valuable proxy for expected stock return and conclude that the measures are well suited to capturing time variation in expected stock market returns. Thus, the evidence on the validity of these COC measures is quite mixed and still emerging. Finally, note that all of these measures purport to capture the firm's cost of capital, and not its internal rate of return, the difference being ''abnormal profitability''.

[34] This approach also has the advantage of dampening random variation caused by different estimation procedures; Dhaliwal et al. (2005) and Hail and Leuz (2006) use this approach as well. When all three measures are unavailable for the same firm-year observation, we take the average of as many different measures as are available to keep the sample size as large as possible.

standard deviation, a simple average may not be sufficient when used in a regression. As in Gaver and Gaver (1993) and Guay (1999) we employ common factor analysis to construct a single mean-zero variable (*COCfactor*) that captures variation common to the various cost of capital measures when using them in regression analysis. Finally, we re-run our analysis using each of the measures individually to eliminate the possibility that a particular bias in any one measure is driving the variation in the combined variable.[35]

To proxy for θ, the spread between the IRR and the required rate of return, we employ a notion of firm-specific abnormal profitability. Empirical estimates of this ''abnormal profitability'' are again notoriously difficult to obtain. We proxy for this notion by taking an average of the prior three years' abnormal ROA (AbROA) measured as the difference between ROA of the firm and the industry median for that year. We determine industry via the use of two digit SIC codes (similar to the approach used by Cheng 2005). One advantage of this method is that, unlike our COC measures, AbROA does not rely on market prices and thus it is not correlated with our empirical proxies for COC.

When using ROA or RNOA as our empirical proxy for ROI, we compare them to the weighted average cost of capital. *WACC* is calculated as: $\frac{BVE}{BVD+BVE} \cdot r_E + \frac{BVD}{BVD+BVE} \cdot r_D \cdot (1 - \tau)$, where BVE denotes the book value of equity (Compustat Item #60), BVD denotes the book value of debt (Compustat Items #9 + #34), r_E is cost of equity capital (from above), r_D represents the borrowing cost of debt (interest expense/total debt) and τ is the applicable income tax rate (Compustat Item #15). The applicable tax rate is calculated by year, similar to the methodology in Nissim and Penman (2001).

2.2 Sample selection

Our empirical tests employ data from several sources. Financial statement data are obtained from the *Compustat* annual database. Data for our cost of capital measures comes from *I/B/E/S* as well as Value Line. Our sample covers all firm-year observations with available *Compustat* data and enough data to calculate at least one of the three cost of capital measures we employ, and ranges from 1982 to 2002. We exclude all firm-year observations with SIC codes in the range 6000–6999 (financial companies) because the demarcation between operating and financing activities is not clear in these firms. We eliminate firm-year observations with insufficient data on *Compustat* to compute the primary financial statement variables used in our tests. Finally, in our parametric tests, we eliminate firms where the average compound growth in investments over the past T periods is lower than -50%. Given the average useful life in our sample is 12 years, any firm with an average drop of 50% in growth over 12 years is likely to be a firm in serious decline. These criteria yield a final sample size of 43,680 firm-year observations. The number of observations in any given regression will vary depending on the availability of data necessary for the particular test.

[35] Because of the ongoing debate regarding appropriate ways to measure the cost of capital, we also conduct a robustness check where we simply replace the cost of capital measure with 12% (Dechow et al. 2004). The results remain qualitatively unchanged.

2.3 Empirical methodology and results

We report results based on the time-series means and *t*-statistics of annual cross-sectional regressions (Fama and MacBeth 1973). This approach typically generates a conservative estimate of statistical significance (Loughran and Ritter 2000). Results are qualitatively similar, albeit more statistically significant, when using pooled OLS regressions. Finally, the tests of Corollary 2 and Proposition 6 require the use of changes on the left hand side of the regression, with overlapping periods. The use of overlapping observations induces serial correlation in the regression residuals and the standard errors are biased downward if they are not corrected for this induced autocorrelation. We correct for this using the Generalized Method of Moments (GMM) standard errors with the Newey–West correction (Newey and West 1987), where we set K, the number of over-lapping periods, equal to one.

Although it is important to study our variables in their natural continuous form, we also take steps to check the robustness of our conclusions. To add statistical assurance to the conclusions based on our continuous regression estimations, we estimate another set of regressions where the continuous value of the independent variable is replaced with its annual decile rank. To create decile ranks, the continuous variables are sorted annually into ten equal-sized groups numbered zero to nine each year and then divided by nine. An added benefit of this approach is that the coefficients from these regressions are easily interpretable as the difference in the dependent variable between the top and bottom deciles of the independent variable. This second set of regressions present more conservative statistical tests; the only assumption about the regression's functional form is that the relations are monotonic (Iman and Conover 1979). Accordingly, all of our analysis will be presented using both continuous and rank Fama–MacBeth regressions.

2.3.1 Descriptive statistics

Table 1 presents the descriptive statistics for our sample. After-tax ROE shows a mean of about 9.3% which is consistent with prior work. Cost of capital has a mean (median) of 13% (12%) and thus is consistent with the long-run return of the stock market over the past 70 years. Figure 5 shows the distribution of *PGrowth* (before the elimination of firm-year observations with less than −50% past growth in the regression tests). Note that *PGrowth* is positively skewed with a mean of 29% but a median of only about 14% because the variable is truncated on the downside at −100% and has unlimited upside. The average useful life of the assets in our sample is 12.7 years. Taken together, many of the descriptive statistics are reasonable in magnitude and do not appear to be subject to extremes. One exception is *PGrowth*, which does not appear to be normally distributed. Panel B of Table 1 presents various descriptive information by *PGrowth* decile.

Panel C of Table 1 presents the correlation table between our variables of interest. At a univariate level, the correlation between *ROE* and *PGrowth* is negative and significant at −0.143 indicating preliminary evidence consistent with Proposition 3. Interestingly, the correlation between past growth (*PGrowth*) and the book-to-market ratio is quite low at −0.015. Thus, despite the common interpretation that

Table 1 Descriptive statistics

Panel A: Descriptive Statistics of Entire Sample

Variable	Mean	Std Dev	25%	50%	75%
ROE$_t$	9.3%	23%	2.8%	11.7%	18.7%
ΔROE$_{t+1}$	(.046)	.353	(.114)	(.012)	.060
COC	13%	5%	10%	12%	15%
PGrowth	.29	.58	.06	.14	.31
Conserv	31%	23%	14%	27%	45%
Uselife	12.7	7.5	7.3	11.4	15.9

The full sample consists of 43,680 firm-year observations from 1982 to 2002. Regressions are estimated annually and mean coefficients are presented. T-statistics are calculated based on the time-series of the annual coefficients using the Fama and MacBeth approach, adjusted by the Newey and West (1970) correction for autocorrelation.

ROE is calculated as operating income after depreciation, interest expense and interest income (Compustat Item #170), multiplied by (1-marginal tax rate), and deflated by lagged book value of equity (Compustat Item #60). The marginal tax rates are the same ones used by Nissim and Penman (2001).

Uselife is the gross amount of PPE (Compustat item #7) divided by depreciation expense (Compustat item #125) in the current year. *Conserv* = [(R&D Exp + Adv Exp)/ (R&D Exp + Adv Exp + Capital Expenditures). *Growth*$_t$ is calculated as [(*Total Investments*$_t$/*Total Investments*$_{t-1}$) −1]. *Total Investments* is R&D Exp (Compustat item #45) + Adv Exp (Compustat item #46) + Capital Expenditures (Compustat item #30). *PGrowth* is the geometric mean of *Growth*$_t$ over the previous *T* (*Uselife*) periods starting at date *t–T +1*. Sales is Compustat item #12. *MVE* is the market value of equity (Compustat Item #25 multiplied by Compustat Item #199). The book-to-market ratio *BM* is Compustat Item #60, divided by *MVE*.

COC is the arithmetic average of r_{DIV}, r_{PEG}, and r_{GLS} (see Appendix B for specifications). *COCfactor* is obtained using common factor analysis on the three measures of *COC* listed above. *AbROA* is measured as an average of the prior three years abnormal *ROA* calculated as the difference between the *ROA* for the firm and the industry median, using 2-digit SIC codes. All financial statement variables are winsorized at the 1%and 99% levels.

Panel B: Mean and Medians by Growth Decile

	PGrowthDecile									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
PGrowth	–11%	1%	5%	8%	12%	17%	23%	33%	54%	152%
	–8%	1%	5%	8%	12%	16%	22%	30%	49%	116%
ROE	8%	11%	12%	12%	12%	11%	10%	8%	6%	3%
	9%	12%	12%	13%	13%	13%	12%	12%	10%	8%
COC	15%	13%	13%	13%	13%	13%	13%	13%	13%	14%
	13%	12%	12%	12%	12%	12%	12%	12%	12%	13%
Conserv	30%	28%	29%	30%	31%	32%	35%	35%	37%	35%
	26%	25%	26%	27%	29%	28%	31%	33%	35%	33%
Uselife	12.5	15.8	15.8	15.0	14.1	13.0	11.4	10.5	9.5	9.0
	11.1	14.3	14.4	13.6	12.8	11.8	10.4	9.4	8.2	7.0
MVE	1,531	3,024	4,138	4,203	3,738	2,898	2,421	1,763	1,370	916
	237	601	758	750	587	487	400	334	232	194
BM	.69	.67	.64	.61	.59	.59	.57	.55	.55	.57
	.57	.60	.57	.55	.53	.50	.47	.45	.43	.42
Sales	1,756	3,427	4,601	4,842	3,846	2,797	2,010	1,402	868	476
	352	853	1,052	1,008	744	549	405	292	193	128

In panel B the top number in each cell reports the mean and the bottom number the median.

Table 1 continued

Panel C: Correlation Matrix

	ROE_t	ΔROE_{t+1}	*COC*	*PGrowth*	*Conserv*	*Uselife*	*MVE*	*BM*
ROE_t	–							
ΔROE_{t+1}	(.368)	–						
	<.0001							
COC	(.336)	(.007)	–					
	<.0001	.183						
PGrowth	(.143)	(.056)	.020	–				
	<.0001	<.0001	0.000					
Conserv	(.141)	(.015)	.001	.053	–			
	<.0001	.006	.924	<.0001				
Uselife	.115	.030	(.076)	(.189)	(.370)	–		
	<.0001	<.0001	<.0001	<.0001	<.0001			
MVE	.126	.004	(.154)	(.058)	.023	.023	–	
	<.0001	.431	<.0001	<.0001	<.0001	<.0001		
BM	(.234)	.030	.383	(.015)	(.161)	.138	(.159)	–
	<.0001	<.0001	<.0001	.003	<.0001	<.0001	<.0001	

the book-to-market ratio captures future growth prospects (Penman 1996), its relation with our measure of *past* growth is weak. This further distinguishes our work from others (e.g., Fama and French 2007) who examine ROE as a function of book-to-market ratios. In addition, despite our modeling assumption that the IRR is unaffected by growth, there is reason to doubt that our empirical proxies will exhibit the same properties. The idea that investment growth relates to the cost of capital lies at the heart of investment theory. However, the correlation between *PGrowth*

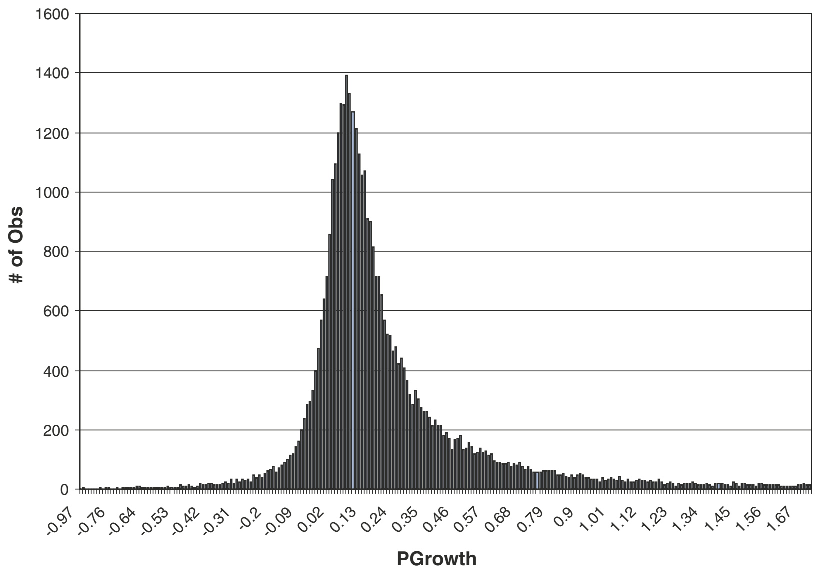

Fig. 5 Number of firm-year observations by level of *PGrowth*. Please refer to Table 1 for a specification of all variables.

and *COC* is low and does not appear to be an issue at 0.020. Later in the paper, our multivariate tests allow us to examine the effect of *PGrowth* on ROE after orthogonalizing with respect to the firm's *COC*. Finally, there is a significant negative correlation of −0.161 between our measure of conservatism (denoted as *Conserv*) and the book-to-market ratio, indicating that our measure of conservatism appears to move in the same direction as this common market-based measure of conservatism, providing some construct validity for our measure.

2.3.2 *Test of Proposition 1*

The quadrant result in Proposition 1 predicts that ROI will exceed, or fall below, IRR depending on whether past growth was moderate or aggressive. In our test of Proposition 1 we use *COC* as a proxy for IRR. Consistent with the conceptual decomposition of IRR into cost of capital and abnormal profitability, we include *AbROA* as a control variable. Because of the dichotomous nature of the dependent variable, we estimate a pooled logistic regression to test Proposition 1. Accordingly, we estimate the probability $Z = \; Pr\, [ROE > COC]$, where the indicator variable $ROE > COC$ is equal to 1 when *ROE* is greater than *COC* and 0 otherwise. To test the North-West Quadrant result, we use as our independent variable the indicator variable ''moderate growth,'' *MG*, which is equal to one when *PGrowth* is less than *COC* by more than 1% (and zero otherwise). The 1% ''stretch parameter'' is chosen to reflect that *COC* is a proxy for IRR and furthermore estimates of the cost of capital are generally considered noisy and imprecise. Similarly, in testing the South-East Quadrant result we use the indicator variable ''aggressive growth,'' *AG*, that is equal to 1 when *PGrowth* exceeds *COC* by more than 1%. Accordingly, we estimate the relations:

$$Z = f(\beta_0 + \beta_1 MG + \beta_2 Uselife + \beta_3 AbROA + \beta_4 Conserv + \beta_5 PGrowth + \epsilon),$$

and

$$Z = f(\gamma_0 + \gamma_1 AG + \gamma_2 Uselife + \gamma_3 AbROA + \gamma_4 Conserv + \gamma_5 PGrowth + \epsilon).$$

The Quadrant result predicts the coefficient β_1 to be positive, whereas γ_1 is expected to be negative. We include *Uselife*, *Conserv*, *PGrowth*, and *AbROA* as control variables and present our results with and without these controls. Moreover, these control variables will be included in all of the subsequent specifications, in order to ensure that alternative, correlated aspects of the analysis do not drive our results.

Panel A of Table 2 presents the North-West quadrant results, showing that the coefficient β_1 is positive and statistically significant across the three specifications. Similarly, Panel B presents the South-East quadrant results with the finding that across the three specifications, the coefficient γ_1 is negative and statistically significant.[36] To be consistent, we compare ROE to the equity cost of capital, yet

[36] Note that because of the requirement that *PGrowth* and COC deviate by 1%, *MG* = 1 does not imply that *AG* = 0.

Table 2 Tests of quadrant result using logistic regressions

Panel A:
$Z = f(\beta_0 + \beta_1 MG + \beta_2 Uselife + \beta_3 AbROA + \beta_4 Conserv + \beta_5 PGrowth + \varepsilon)$

	β_0	β_1	β_2	β_3	β_4	β_5	$Pr > \chi^2$
Coefficient	171	**.340**					291
(P-value)	<.0001	**<.0001**					<.0001
Coefficient	.675	**.082**	.010	–.141			2145
(P-value)	<.0001	**.0004**	<.0001	.0180			<.0001
Coefficient	.436	**.084**	.018	–.061	.449	.014	2234
(P-value)	<.0001	**.0003**	<.0001	.3812	<.0001	.0413	<.0001

Panel B:
$Z = f(\gamma_0 + \gamma_1 AG + \gamma_2 Uselife + \gamma_3 AbROA + \gamma_4 Conserv + \gamma_5 PGrowth + \varepsilon)$

	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	$Pr > \chi^2$
Coefficient	.161	**–.375**					347
(P-value)	<.0001	**<.0001**					<.0001
Coefficient	.782	**–.357**	.010	–.139			2158
(P-value)	<.0001	**<.0001**	<.0001	<.0409			<.0001
Coefficient	.544	**–.351**	.017	–.050	.446	.016	2246
(P-value)	<.0001	**<.0001**	<.0001	.4335	<.0001	.0218	<.0001

Please refer to Table 1 for a specification of all variables.
In addition: $Z = Pr[ROE{>}COC]$, where the indicator variable *ROE>COC* is equal to 1 if ROE is greater than COC; and 0 otherwise. $MG = 1$ if $PGrowth_t$ is less than *COC* by more than 1% and 0 otherwise. $AG = 1$ if $PGrowth_t$ is greater than *COC* by more than 1% and 0 otherwise.

ROA and RNOA are compared to WACC in unreported tests. Our findings for ROA and RNOA are similar to the ones for ROE. In summary, the data analysis lends support to the prediction of Proposition 1.

2.3.3 Test of Proposition 3

The monotonicity result in Proposition 3 suggests testing whether ROE is decreasing in the geometric mean of past growth in investments over the prior T periods. Specifically, we ask whether the coefficient ρ_1 is negative in the following regression:

$$ROE_t = \rho_0 + \rho_1 PGrowth + \rho_2 Uselife + \rho_3 Conserv + \rho_4 COCfactor + \rho_5 AbROA + \epsilon_t.$$

2.3.4 Test of Corollary 2

Next, we explore how future changes in ROE relate to changes in current growth relative to past growth. Our prediction is that the larger the deviation in the current period's growth from the (assumed constant) average growth of the prior $T-1$ periods, the larger the drop in next period's ROE relative to current ROE. To operationalize this prediction empirically, we adopt a changes specification on the LHS in *ROE* and a deviation from prior growth on the RHS of the regression equation:

$$\Delta ROE_{t+1} = \rho_0 + \rho_1 \cdot [Growth_t - PGrowth] + \rho_2 \cdot Uselife + \rho_3 Conserv + \rho_4 COCfactor + \epsilon_{t+1}.$$

Here, $\Delta ROE_{t+1} = ROE_{t+1} - ROE_t$. The right-hand side variable $[Growth_t - PGrowth]$ is the difference between the current period's growth in investments and the geometric mean of growth in the prior $T-1$ periods.[37] Panel B of Table 1 presents the mean levels of ROE as a function of *PGrowth* deciles and provides descriptive evidence regarding Proposition 3. As growth increases we see a general negative trend in ROE. Surprisingly, firms in the first decile of *PGrowth* have lower ROE's and there is a large increase in the 2nd decile. This pattern is not predicted by our theory. However, the firms in this first decile have a mean decline in *PGrowth* of about 11%; coupling that with an average *Uselife* of 12 years makes it clear that these are firms in severe decline. Thus, *ex-post*, although not predicted by the above model, it appears reasonable that the firms in the first decile of *PGrowth* would not be as profitable and display lower levels of ROE.

Proposition 3 is tested statistically using the empirical equations above. The results in Panel A of Table 3 show that the coefficient on *PGrowth*, is negative and statistically significant with a negative *t*-value of 4.83 in Model 1. Model 2 replaces the continuous variables by their decile ranks and finds similar results. As mentioned earlier, the coefficient in this regression can be interpreted to give a better sense of the economic significance of the effect. The coefficient of -0.037 indicates that the difference in ROI is about 4% when moving from the top to bottom deciles of *PGrowth* holding everything else constant. Panel B of Table 3 presents the results for Corollary 2, using the future changes in ROE specification. Similar to the levels result, the coefficient on ρ_1 is negative and statistically significant across both continuous and rank specifications. In addition, the coefficient on the rank regression is similar in economic magnitude to the levels specification at 3%.[38]

2.3.5 Test of Proposition 5

After imposing uniform cash flows and geometric depreciation, the first result in Proposition 5 states that ROE is a decreasing and convex function of past growth. Thus, a simple linear approximation will not adequately capture the impact of growth on ROE. Accordingly, we estimate an empirical relation similar to the one above, but include a quadratic term to capture the convexity:

$$ROE_t = \rho_0 + \rho_1 \cdot PGrowth + \rho_2 \cdot Uselife + \rho_3 \cdot Conserve + \rho_4 \cdot COCfactor + \rho_5 \cdot AbROA + \rho_6 \cdot Conserv \cdot PGrowth + \rho_7 \cdot [PGrowth]^2 + \epsilon_t.$$

[37] In unreported tests, we also estimate this changes specification using first differences in *Uselife*, *Conserv* and *COCfactor* as the control variables instead of the levels. Results are quantitatively similar.

[38] As indicated above, we also examine these same tests using ROA and RNOA instead of ROE, and WACC instead of COC. Our results are qualitatively similar. The coefficients on *PGrowth* and the current deviation from *PGrowth* are negative in all four specifications.

Table 3 Time-series means and *t*-statistics for coefficients from annual cross-sectional regressions of *ROE* on growth

Panel A:

$$ROE_t = \rho_0 + \rho_1 PGrowth + \rho_2 Uselife + \rho_3 Conserv + \rho_4 COCfactor + \rho_5 AbROA + \in_t$$

	ρ_0	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	**Adj.R^2**
Model 1	.112	**–.012**	.000	–.009	–.060	.539	28.1%
	21.22	**–4.83**	2.57	–1.33	–12.97	17.25	16.43
Ranks Replacing Continuous Values							
Model 2	.069	**–.037**	.024	.003	–.117	1.949	24.6%
	8.62	**–4.87**	3.72	0.64	–15.46	22.12	19.92

Panel B:

$$\Delta ROE_{t+1} = \rho_0 + \rho_1[PGrowth_t - PGrowth] + \rho_2 Uselife + \rho_3 Conserv + \rho_4 COCfactor + \in_{t+1}$$

	ρ_0	ρ_1	ρ_2	ρ_3	ρ_4	**Adj.R^2**
Model 3	–.028	**–.004**	.001	–.019	–.004	1.5%
	–4.56	**–3.90**	2.67	–3.18	–1.01	4.93
Ranks Replacing Continuous Values						
Model 4	–.020	**–.031**	.026	–.007	–.001	1.3%
	–2.76	**–7.76**	3.66	–1.40	–0.13	4.80

Please refer to Table 1 for a specification of all variables.

Table 4 Time-series means and *t*-statistics for coefficients from annual cross-sectional regressions of *ROE* on growth and convexity

$$ROE_t = \rho_0 + \rho_1 PGrowth + \rho_2 Uselife + \rho_3 Conserv + \rho_4 COCfactor + \rho_5 AbROA + \rho_6 Conserv \cdot PGrowth + \rho_7 [PGrowth]^2 + \in_t$$

	ρ_0	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	**Adj.R^2**
Mean Coefficient	.118	**–.032**	.000	–.010	–.059	.548		**.004**	28.4%
t-statistic	20.40	**–6.42**	1.77	–1.40	–12.91	16.74		**2.67**	16.84
Mean Coefficient	.118	**–.032**	.000	–.008	–.059	.549	–.003	**.004**	28.6%
t-statistic	20.87	**–6.45**	1.78	–1.03	–12.96	16.82	–0.30	**2.92**	16.81

Please refer to Table 1 for a specification of all variables.

If the relationship between growth and *ROE* is convex as predicted by the model, then we would expect the coefficient on ρ_7 to be positive in this regression. Note that we estimate the regression with and without the cross-partial effects (ρ_6) from Proposition 5.[39] The results are presented in Table 4. In both empirical estimations, the bolded coefficient ρ_7 is positive and statistically significant and the main effect on ρ_1 is still negative.[40]

[39] We do not estimate rank regressions for this particular empirical specification. The process of creating decile ranks after squaring is ordinal because it preserves the monotonic relationship. Squaring a variable is a simple monotonic transformation and recall that this is the primary attribute of rank regressions (Iman and Conover 1979). Thus, the rank variable will have the exact values as the primary value after decile ranking and adds no new information or variation to the regression estimation.

[40] We find similar results when estimating this regression using RNOA. However, we do not obtain statistically significant results when using ROA.

Table 5 *ROE* levels by *Conserv* and *Growth* terciles

		Conserv		
		Low	Medium	High
PGrowth Tercile	Low	.193	.217	.152
		.204	.213	.185
	Medium	.192	.196	.115
		.203	.209	.174
	High	.145	.144	.029
		.184	.185	.105
Difference Between High and Low ***PGrowth***		**.048**	**.073**	**.123**
		.020	**.030**	**.080**

Please refer to Table 1 for a specification of all variables. The top number in each cell reports the mean and the bottom number the median.

2.3.6 Test of Proposition 6

Proposition 2, the second result in Proposition 5, and Proposition 6 all predict that more conservative accounting will increase the negative slope (in absolute terms) of the previously discussed relation between growth and *ROE*. This proposition is formally tested as follows:

$$\begin{aligned} ROE_t =& \rho_0 + \rho_1 \cdot PGrowth + \rho_2 \cdot Uselife + \rho_3 \cdot Conserv + \rho_4 \cdot COCfactor \\ &+ \rho_5 \cdot AbROA + \rho_6 \cdot Conserv \cdot PGrowth + \epsilon_t. \end{aligned}$$

We expect the coefficient ρ_6 to be negative indicating the slope will continue to decrease as the degree of conservatism (*Conserv*) increases. Finally, although not predicted by the theory, we also explore whether the empirical changes specification from Corollary 2 holds in this case. Specifically, we test whether the cross-partial result is also found in a deviation from prior growth. Accordingly, we estimate the following regression:

$$\begin{aligned} \Delta ROE_{t+1} =& \rho_0 + \rho_1 \cdot [Growth_t - PGrowth] + \rho_2 \cdot Uselife + \rho_3 \cdot Conserv \\ &+ \rho_4 \cdot COCfactor + \rho_5 \cdot Conserv \cdot [Growth_t - PGrowth] + \epsilon_{t+1}. \end{aligned}$$

Once again, the cross-partial result on the coefficient ρ_5 is also expected to be negative. Table 5 presents descriptive statistics consistent with the property of decreasing returns. Starting with the low *Conserv* column, we find that the mean *ROE* falls from 19.3% to 14.5% when moving from low to high *PGrowth*. This drop of 4.8% is consistent with our theory. Further, we find that as conservatism increases, the difference increases to 7.3%, then to 12.3%, as we move from low to high *Conserv* terciles respectively (unreported tests reveal that these differences are statistically significant).

Table 6 presents the parametric tests of Proposition 6. Again, Panel A presents the level of ROE and Panel B presents the changes in ROE. In Model 1, the cross-partial variable is added and the coefficient on ρ_6 is found to be negative and significant as predicted by the theory. However, in the ranks regression (Model 2),

Table 6 Time-series means and *t*-statistics for coefficients from annual cross-sectional regressions of *ROE* and ΔROE on growth and conservatism

Panel A:

$$ROE_t = \rho_0 + \rho_1 PGrowth + \rho_2 Uselife + \rho_3 Conserv + \rho_4 COCfactor + \rho_5 AbROA + \rho_6 Conserv \cdot PGrowth + \epsilon_t$$

	ρ_0	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	**Adj. R^2**
Model 1	.111	**–.010**	.000	–.002	–.059	.544	**–.020**	28.3%
	20.99	**–3.06**	2.48	–.33	–12.94	17.13	**–2.98**	16.56
Ranks Replacing Continuous Values								
Model 2	.114	**–.063**	.039	.001	–.194	3.18	**.005**	24.6%
	8.34	**–3.73**	3.95	.61	–15.33	27.48	**.41**	20.07

Panel B:

$$\Delta ROE_{t+1} = \rho_0 + \rho_1 [PGrowth_t - PGrowth] + \rho_2 Uselife + \rho_3 Conserv + \rho_4 COCfactor + \rho_5 Conserv \cdot [Growth_t - PGrowth] + \epsilon_{t+1}$$

	ρ_0	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	**Adj. R^2**
Model 3	–.028	**–.002**	.001	–.019	–.004	**–.012**	1.6%
	–4.60	**–3.20**	2.70	–3.18	–1.04	**–2.54**	5.27
Ranks Replacing Continuous Values							
Model 4	–.017	**–.014**	.025	–.009	–.001	**–.019**	1.3%
	–2.46	**–2.66**	3.63	–1.96	–.15	**–3.53**	4.74

Please refer to Table 1 for a specification of all variables.

the interaction term is insignificant; thus, there are mixed results across the two specifications. Panel B presents the changes regression and, once again, the interaction term is negative and significant as predicted for both continuous and rank specifications.[41]

Taken together, we conclude that our model predictions are generally supported by the data. This suggests that the simplifying assumptions of the model may not be overly distortive in capturing the effects of conservatism and growth. The preceding analysis also suggests that our empirical proxies are reasonably well suited to capture the underlying constructs.

3 Concluding remarks

ROI is arguably the most widely-used measure of firm profitability. In this paper, we have examined the fundamental issue of how ROI relates to the underlying economic profitability of a firm's investment projects. Our main conclusion is that accounting conservatism and past growth in investments jointly determine how ROI compares to the underlying internal rate of return. Given conservative accounting, faster growth tends to depress ROI and this decline will be more pronounced for more conservative accounting rules. Conversely, the impact of a higher degree of conservatism on ROI will depend on whether past growth rates are above or below a

[41] In unreported tests, when using ROA instead of ROE, ρ_1 and ρ_5 are negative and statistically significant in both of the empirical specifications. Further, the results are larger in economic significance. In contrast, for RNOA, the coefficients in Panel A of Table 6 are not statistically significant.

critical level, given by the internal rate of return of the firm's projects. A major contribution of our analysis is the derivation of a closed-form expression for the steady-state ROI expressed as a function of several key variables: conservatism, growth in new investments, the useful life of assets, and the internal rate of return of projects available to the firm.

Our analytical results suggest a series of hypotheses, which we test using a large-scale panel data set that spans a 20-year time period. Our choice of empirical proxies for the variables mirrors the nature of the constructs used in deriving the analytical results. Overall, we find consistent support for our predictions regarding the behavior of accounting rates of return, under a variety of specifications (including both levels and changes). In particular, return on equity, our primary proxy for ROI, is found to satisfy the ''quadrant result,'' as well as to behave in a manner predicted by the model with regard to growth, accounting conservatism, and the interaction of these variables.

The thrust of our analysis has been to understand distortions in the accounting rate of return relative to the underlying economic profitability. Our analysis may also lend itself to a reverse approach: inferring economic profitability from observed ROIs in conjunction with other firm characteristics including growth, the useful life of assets, the proportion of intangible assets etc. This type of inference has long been a major challenge to economists seeking to assess the competitiveness of particular industries.

Our modeling framework has envisioned a representative firm with exogenously specified levels of economic profitability and exogenous growth rates in investments. We have thus abstracted away from issues related to the specific structure of the product markets in which the firm is competing. In future work, it would be of interest to develop a richer model of imperfect competition that entails such elements as the formation of product prices, new investments and entry or exit decisions. As a general matter, such an expanded model should make it possible to relate observed industry characteristics to the accounting profitability for firms in that industry.

Finally, our data analysis indicates that our empirical measure of conservatism and other empirical proxies provide a reasonable approximation of the underlying constructs. While this paper has focused on the accounting rate of return, it is natural to ask how our findings extend to other key financial ratios such as the Market-to-Book or the Price-Earnings ratio. Extending our analysis along these lines would not only be of interest in its own right but would also facilitate the comparison to the rapidly growing literature that has examined conservatism in its relation to equity values.

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Appendix A

Proof of Lemma 1 Direct substitution yields

$$\begin{aligned}\sum_{i=1}^{t} RI_i \cdot \gamma^i =& \gamma \cdot [c_1^0 - (d_1 + r) \cdot b^o] + \gamma^2 \cdot [c_2^0 - (d_2 + r \cdot (1 - d_1)) \cdot b^o] + \cdots \\ &+ \gamma^t \cdot [c_t^0 - (d_t + r \cdot (1 - d_1 - \ldots d_{t-1})) \cdot b^o].\end{aligned} \tag{10}$$

Collecting coefficients for each of the variables $(d_1, \ldots, d_t)$ on the right-hand side of the above equation, the coefficient for d_i is:

$$\gamma^i - r \cdot [\gamma^{i+1} + \cdots + \gamma^t] = \gamma^{i+1} - r \cdot [\gamma^{i+2} + \cdots + \gamma^t] = \cdots = \gamma^t.$$

Thus,

$$\sum_{i=1}^{t} RI_i^0 \cdot \gamma^i = \sum_{i=1}^{t} \gamma^i \cdot c_i^0 - [(1 - \gamma^t) + \gamma^t \cdot (d_1 + \cdots + d_t)] \cdot b^0$$

By the definition of neutral accounting,

$$\sum_{i=1}^{t} \gamma^i \cdot c_i^0 - [(1 - \gamma^t) + \gamma^t \cdot (d_1^* + \cdots + d_t^*)] \cdot b^0 = 0.$$

Therefore $\sum_{i=1}^{t} d_i \geq \sum_{i=1}^{t} d_i^*$ is equivalent to $\sum_{i=1}^{t} RI_i^0 \cdot \gamma^i \leq 0$. □

Proof of Proposition 1 The expression for ROI at date T is given in (1). Therefore $ROI_T(\vec{\lambda}) \geq r$ is equivalent to:

$$RI_T^o + (1 + \lambda_1) \cdot RI_{T-1}^o + (1 + \lambda_1) \cdot (1 + \lambda_2) \cdot RI_{T-2}^o + \cdots + \prod_{i=1}^{T-1} (1 + \lambda_i) \cdot RI_1^o \geq 0, \tag{11}$$

where $RI_t^o \equiv c_t^o - d_t \cdot b^o - r \cdot b^o(1 - \sum_{i=1}^{t-1} d_j)$ denotes the residual income of the representative project $\mathcal{P} = (b^o, c_1^o, \ldots, c_T^o)$. Lemma 1 shows that for any conservative depreciation schedule $(d_1, \ldots, d_T)$:

$$\sum_{i=1}^{t} RI_i^o \cdot \gamma^i \leq 0 \tag{12}$$

for all $1 \leq t \leq T - 1$. The claim therefore amounts to showing that for any $T{-}1$ tuple $(RI_1^o, \ldots, RI_{T-1}^o)$ satisfying (12), inequality (11) will be met if $\lambda_t \leq r$. Since $\Sigma_{i=1}^{T} RI_i^o \cdot \gamma^i = 0$, inequality (11) can equivalently be written as:

$$RI_{T-1} \cdot [(1+\lambda_1) - \gamma^{-1}] + RI_{T-2} \cdot [(1+\lambda_1)(1+\lambda_2) - \gamma^{-2}] + \cdots \\ + RI_1 \cdot \left[\prod_{i=1}^{T-1}(1+\lambda_i) - \gamma^{-(T-1)}\right] \geq 0. \tag{13}$$

The inequalities in (12) can be represented in matrix form as:

$$\Gamma \cdot \vec{RI}^0 \leq 0 \tag{14}$$

where

$$\Gamma = \begin{bmatrix} \gamma & & & & \\ \gamma & \gamma^2 & & & \\ \gamma & \gamma^2 & \gamma^3 & & \\ \cdot & \cdot & \cdot & \ddots & \\ \cdot & \cdot & \cdot & \cdot & \\ \gamma & \gamma^2 & \gamma^3 & \cdots & \gamma^{T-1} \end{bmatrix}$$

and $\vec{RI}^0 = (RI_1^0, \ldots, RI_{T-1}^0)$. By Farkas Lemma (see Rockafellar 1970), (13) holds for any vector satisfying (14) if and only if there exists a non-negative row-vector $v' = (v_1, \ldots, v_{T-1})$ such that:

$$v' \cdot \Gamma = \begin{pmatrix} \gamma^{1-T} - \prod_{i=1}^{T-1}(1+\lambda_i) \\ \vdots \\ \gamma^{-1} - (1+\lambda_1) \end{pmatrix}. \tag{15}$$

Since Γ is a diagonal matrix, the system of equations in (15) can be solved explicitly, yielding:

$$\begin{aligned} v_{T-1} &= \gamma^{-(T-1)}[\gamma^{-1} - (1+\lambda_1)] \\ v_{T-2} &= \gamma^{-(T-2)}(1+\lambda_1)[\gamma^{-1} - (1+\lambda_2)] \\ &\vdots \\ v_1 &= \gamma^{-1} \cdot \textstyle\prod_{i=1}^{T-1}(1+\lambda_i)[\gamma^{-1} - (1+\lambda_{T-1})] \end{aligned}.$$

It follows that $v_t \geq 0$ if and only if $\gamma^{-1} \geq (1+\lambda_t)$, or equivalently, $r \geq \lambda_t$.

If the annual growth rates all exceed r, the claim is that inequality (13) reverses. The same line of arguments as before applies with the vector $w' \geq 0$, required by Farkas Lemma, given by:

$$w_t = -v_t \geq 0.$$

Finally, for liberal accounting, the vector of residual income numbers satisfies:

$$\Gamma \cdot \vec{RI}^0 \geq 0.$$

Therefore the inequalities are ‘‘flipped,’’ such that (13) holds provided $\lambda_t \geq r$ and the opposite is true for $\lambda_t \leq r$. □

Proof of Proposition 2 We show that:

$$ROI_T(\vec{\lambda}, \vec{d} + \vec{u}) \geq ROI_T(\vec{\lambda}, \vec{d}), \tag{16}$$

provided that $\sum_{i=1}^{t} u_i \geq 0$ and $\lambda_t \leq r$ for $1 \leq t \leq T-1$. It will be convenient to denote $S_t \equiv \sum_{i=1}^{t} u_i$. Referring back to the definition of ROI_T in (1), the inequality in (16) is equivalent to:

$$\begin{aligned} &ROI_T(\vec{\lambda}, \vec{d}) \cdot \left[S_{T-1} + (1+\lambda_1) \cdot S_{T-2} + \cdots \prod_{i=1}^{T-2} (1+\lambda_i) \cdot S_1 \right] \geq \\ &-S_{T-1} + (S_{T-1} - S_{T-2})(1+\lambda_1) + (S_{T-2} - S_{T-3})(1+\lambda_1)(1+\lambda_2) \\ &+ \cdots (S_1 - S_0) \prod_{i=1}^{T-1} (1+\lambda_i), \end{aligned} \tag{17}$$

where, by definition, $S_0 = 0$. We first note that:

$$ROI_T(\vec{\lambda}, \vec{d}) \cdot S_{T-1} \geq -S_{T-1} + (1+\lambda_1) \cdot S_{T-1}$$

because $S_{T\text{-}1} \geq 0$, $\lambda_1 \leq r$ and $ROI_T(\vec{\lambda}, \vec{d}) \geq r$. The latter claim is implied by Proposition 1, since the accounting is conservative and $\lambda_t \leq r$ for all $1 \leq t \leq T-1$. Turning next to $S_{T\text{-}2}$, the same arguments apply since:

$$ROI_T(\vec{\lambda}, \vec{d})(1+\lambda_1) \cdot S_{T-2} \geq -(1+\lambda_1) \cdot S_{T-2} + (1+\lambda_1)(1+\lambda_2) \cdot S_{T-2}.$$

Proceeding inductively, we conclude that for any $1 \leq t \leq T-2$:

$$ROI_T(\vec{\lambda}, \vec{d}) \cdot \prod_{i=1}^{T-t-1} (1+\lambda_i) \cdot S_t \geq -\prod_{i=1}^{T-t-1} (1+\lambda_i) \cdot S_t + \prod_{i=1}^{T-t} (1+\lambda_i) \cdot S_t,$$

provided $S_t \geq 0$, $\lambda_t \leq r$ and $ROI_T(\vec{\lambda}, \vec{\delta}) \geq r$; thus, (17) holds, as was to be shown. Finally, when growth is aggressive, i.e., $\lambda_t \geq r$, note that all inequalities are reversed since by Proposition 1 $ROI_T(\vec{\lambda}, \vec{d}) \leq r$ whenever the accounting is conservative and $\lambda_t \geq r$. □

Proof of Proposition 3 To demonstrate that $ROI_T(\vec{\lambda})$ is monotone decreasing in each λ_t, we first establish the following technical result.

Claim The function

$$f(\vec{\lambda}) = \frac{\sum_{i=0}^{T-1} a_i(\vec{\lambda})}{\sum_{i=0}^{T-1} \omega_i \cdot a_i(\vec{\lambda})}$$

is monotone decreasing in λ_t provided: (i) $\omega_{i+1} \geq \omega_i$ and

$$(ii)\ \frac{\frac{\partial}{\partial\lambda_t}a_i(\vec{\lambda})}{a_i(\vec{\lambda})} \le \frac{\frac{\partial}{\partial\lambda_t}a_{i+1}(\vec{\lambda})}{a_{i+1}(\vec{\lambda})} \tag{18}$$

for all $0 \le i \le T{-}2$.

Proof of Claim The numerator of the derivative of $f(\vec{\lambda})$ with respect to λ_t is given by:

$$\sum_{i=0}^{T-1}\sum_{j=i+1}^{T-1}(\omega_j - \omega_i)\left[\frac{\partial}{\partial\lambda_t}a_i(\vec{\lambda})\cdot a_j(\vec{\lambda}) - \frac{\partial}{\partial\lambda_t}a_j(\vec{\lambda})\cdot a_i(\lambda)\right].$$

Therefore $\frac{\partial}{\partial\lambda_t}f(\vec{\lambda}) \le 0$ whenever conditions (i) and (ii) are met.

To apply the above Claim, we recall that $Inc_t^o = c_t^o - d_t \cdot b^o$ and set:

$$\begin{aligned}
a_0(\vec{\lambda}) &= Inc_T^0\\
a_1(\vec{\lambda}) &= Inc_{T-1}^0\cdot(1+\lambda_1)\\
&\ \vdots\\
a_{T-1}(\vec{\lambda}) &= Inc_1^0\cdot\textstyle\prod_{i=1}^{T-1}(1+\lambda_i).
\end{aligned}$$

Recalling that $BV_t^o = (1-\sum_{i=1}^{t-1}d_i)\cdot b^o$, we also set:

$$\omega_0 = \frac{BV_{T-1}^0}{Inc_T^0},\quad \omega_1 = \frac{BV_{T-2}^0}{Inc_{T-1}^0},\ldots,\quad \omega_{T-1} = \frac{BV_0^0}{Inc_1^0}.$$

Straightforward differentiation shows that the functions $a_t(\vec{\lambda})$ in (18) satisfy the elasticity conditions in part (ii) of the Claim. Finally, by neo-conservatism, RI_t^0 is increasing in t. It follows that

$$ROI_{t+1}^0 - r = \frac{RI_{t+1}^0}{BV_t^0} > ROI_t^0 - r = \frac{RI_t^0}{BV_{t-1}^0}$$

since $BV_{t-1}^0 \ge BV_t^0$. We conclude that

$$ROI_1^0 \equiv \frac{1}{\omega_{T-1}} \le ROI_2^0 \equiv \frac{1}{\omega_{T-2}} \le \cdots ROI_T^0 = \frac{1}{\omega_0}$$

implying that $\omega_0 \le \omega_1 \le \cdots \le \omega_{T-1}$, as required by condition (i) in the Claim. □

Proof of Proposition 4 We first show that

$$RI_T^\lambda \equiv Inc_T - \lambda\cdot BV_{T-1}$$

is independent of the depreciation schedule $(d_1,\ldots,d_T)$, where

$$Inc_T \equiv Inc_T^o + Inc_{T-1}^o \cdot (1+\lambda) + \cdots + Inc_1^o \cdot (1+\lambda)^{T-1}$$

and

$$BV_{T-1} \equiv BV_{T-1}^o + BV_{T-2}^o \cdot (1+\lambda) + \cdots + BV_0^o \cdot (1+\lambda)^{T-1}.$$

Pulling out the factor $(1 + \lambda)^T$, we observe that:

$$RI_T^{\lambda} = (1+\lambda)^T \cdot \left[\sum_{t=1}^{T} RI_t^o(\lambda) \cdot (1+\lambda)^{-t}\right], \tag{19}$$

where $RI_t^o(\lambda) \equiv Inc_t^o - \lambda \cdot BV_{t-1}^o$. Since the residual income numbers $RI_t^o(\lambda)$ have the same present value as the underlying cash flows, the right hand side of (19) is equal to:

$$(1+\lambda)^T \cdot \left[\sum_{t=1}^{T} c_t^o \cdot (1+\lambda)^{-t} - b^o\right],$$

which obviously is independent of $(d_1, \ldots, d_T)$. If one chooses the depreciation schedule $(d_1^*, \ldots, d_T^*)$, which is neutral for $\mathcal{P}$, then by definition:

$$Inc_T^* = r \cdot MV_{T-1},$$

and

$$BV_{T-1}^* = MV_{T-1}.$$

Using the above observation that RI_T^{λ} is invariant to the depreciation schedule, we conclude that for any $(d_1, \ldots, d_T)$:

$$(r-\lambda) \cdot MV_{T-1} = Inc_T - \lambda \cdot BV_{T-1},$$

or equivalently:

$$ROI_T(\lambda, \delta) = \lambda + (r-\lambda) \cdot \frac{MV_{T-1}(\lambda, r)}{BV_{T-1}(\lambda)}. \tag{20}$$

Proof of Lemma 2 Differentiating the function $h(s)$, we obtain:

$$h'(s) = \frac{(1+s)^{T-1}}{[(1+s)^T - 1]^2} \cdot \left[(1+s)^{T+1} - (1+s+sT)\right] > 0; \tag{21}$$

$$h''(s) = T \cdot (1+s)^{T-2} \cdot \left[\frac{(2+s) \cdot [1-(1+s)^T] + sT \cdot (1+(1+s)^T)}{[(1+s)^T - 1]^3} \right]. \tag{22}$$

The monotonicity of $h(\cdot)$ in (21) follows from Bernoulli's inequality. To establish convexity, first note that as $s \to 0$, $(22) \to \frac{T^2-1}{6T} > 0$. Assume henceforth that $s \neq 0$. We can ignore the positive $T \cdot (1+s)^{T-2}$ expression in front of (22). Now, for $s \neq 0$, the denominator of (22) has the same sign as s. The numerator equals $(1-T) < 0$ as $s \to -1$, and its value as well as its derivative equal 0 at $s \to 0$. Further, its second derivative is given by the expression $T(T-1)(T+1)s(1+s)^{T-2}$, which has the same sign as s. Combining these facts, the numerator of (22) is monotone increasing and has an inflection point at $s = 0$, i.e., it has the same sign as s everywhere, thereby proving that $(22) > 0$ for all s. To prove that the ratio of $h'(\cdot)$ to $h''(\cdot)$ increases in s, we use (21) and (22) to obtain the simplified ratio:

$$\frac{h'(s)}{h''(s)} = \frac{(1+s) \cdot [(1+s)^T - 1] \cdot [(1+s)^{T+1} - s(1+T) - 1]}{(2+s) \cdot [1-(1+s)^T] + s \cdot T \cdot [1+(1+s)^T]}. \tag{23}$$

Letting $z = (1+s) > 0$, (23) can be re-expressed as:

$$\frac{z \cdot (z^T - 1) \cdot [z^{T+1} - z - T(z-1)]}{(1+z) \cdot (1-z^T) + T \cdot (z-1) \cdot (1+z^T)} \tag{24}$$

The key to the proof is to recognize that $(z-1)^3$ is a factor of both the numerator and denominator of (24). Dividing through by this term, (24) can then be reduced to the following ratio of polynomials with positive coefficients:

$$\frac{\left(\sum_{i=0}^{T-1} z^{i+1}\right) \cdot \left(\sum_{i=0}^{T-1} (T-i)z^i\right)}{\sum_{i=1}^{T-1} i(T-i)z^{i-1}} \tag{25}$$

$$= \frac{\sum_{i=1}^{T} i(2T-i+1)z^i + \sum_{i=T+1}^{2T-1} (2T-i+1)(2T-i)z^i}{2 \cdot \sum_{i=0}^{T-2} (i+1)(T-i-1)z^i}. \tag{26}$$

We ignore the constant and differentiate (26) with respect to z. The resulting numerator, which we must show is positive, is the following polynomial of order $(3T-4)$:

$$\begin{aligned} &\left(\sum_{i=0}^{T-2}(i+1)(T-i-1)z^i\right) \cdot \left[\sum_{i=0}^{T-1}(i+1)^2(2T-i)z^i + \sum_{i=T}^{2T-2}(i+1)(2T-i)(2T-i-1)z^i\right] \\ &- \left(\sum_{i=0}^{T-3}(i+1)(i+2)(T-i-2)z^i\right) \cdot \left[\sum_{i=1}^{T} i(2T-i+1)z^i + \sum_{i=T+1}^{2T-1}(2T-i+1)(2T-i)z^i\right]. \end{aligned} \tag{27}$$

For $1 \leq i \leq (3T-4)$, the coefficient of z^i in (27) can then be simplified as follows:

Range of i	Coefficient of i
$i \leq (T-1)$	$\frac{1}{60} \cdot (1+i) \cdot (2+i) \cdot (3+i) \cdot [i^2(T+3) + i(7-11T) + 20T(T-1)]$
$i = T$	$\frac{1}{60} \cdot T \cdot (T+1) \cdot (T-1) \cdot [T^3 + 18T^2 + 71T - 162]$
$(T+1) \leq i \leq (2T-3)$	$\frac{1}{60} \cdot \begin{pmatrix} -84i - 190i^2 - 150i^3 - 50i^4 - 6i^5 + 246t + 784iT + 760i^2T \\ +270i^3T + 20i^4T - 4i^5t - 665T^2 - 1005iT^2 - 300i^2T^2 \\ +100i^3T^2 + 40i^4T^2 + 215T^3 - 335iT^3 - 540i^2T^3 - 150i^3T^3 \\ +485T^4 + 785iT^4 + 260i^2T^4 - 341T^5 - 205iT^5 + 60T^6 \end{pmatrix}$
$i \geq (2T-2)$	$\frac{1}{60} \cdot (T+1) \cdot (3T-i) \cdot [3T-1-i] \cdot [3T-2-i]$ $\cdot [3T-3-i] \cdot [3i+7-4T]$

It can be verified that each of these coefficients is positive for any suitable values of T and i (details are available on request). As the polynomial in (27) is defined over the positive real line, we thus obtain the desired result that $h'(\cdot)$ is (strictly) log-concave everywhere. □

Proof of Proposition 5 Direct substitution yields:

$$ROI_T(\lambda,\delta) = \lambda + \frac{(\lambda+\delta)[1-(1-\delta)^T]}{[(1+r)^T-1]} \cdot \frac{r(1+r)^T[(1+\lambda)^T-1] - \lambda(1+\lambda)^T[(1+r)^T-1]}{\lambda(1+\lambda)^T[1-(1-\delta)^T] + \delta(1-\delta)^T[1-(1+\lambda)^T]}. \tag{28}$$

The monotonicity of $ROI_T(\lambda,\delta)$ in λ follows from Proposition 3 and the observation that geometric depreciation results in neo-conservative accounting when cash flows are uniform and $\delta > -r$. To prove convexity in λ, we let $p = -\delta$ and express (28) in the following form:

$$ROI_T(\lambda,p) = p + (p-\lambda) \cdot \left[\frac{h(p)-h(r)}{h(\lambda)-h(p)}\right]. \tag{29}$$

Differentiating (29) twice with respect to λ, we find that:

$$\frac{\partial^2}{\partial\lambda^2}(ROI_T(\lambda,p)) = \frac{[h(r)-h(p)]}{[h(\lambda)-h(p)]^4} \cdot ([h(\lambda)-h(p)] \cdot Q(\lambda,p)), \tag{30}$$

where $Q(\lambda,p) = -h''(\lambda)(\lambda-p)[h(\lambda)-h(p)] - 2h'(\lambda) \cdot [h(\lambda)-h(p)-h'(\lambda)(\lambda-p)]$. We will demonstrate that for any $\lambda \neq p, [h(\lambda)-h(p)] \cdot Q(\lambda,p) > 0$. Since $h(\cdot)$ is an increasing function, (30) then immediately yields the desired results for conservative accounting, i.e., $h(r) > h(p)$. Conversely, for liberal accounting $ROI_T(\cdot, p)$ is concave in λ since (30) is negative when $h(r) < h(p)$.

Fix some $\lambda > -1$ and consider the behavior of $Q(\cdot)$ in p. Note that $Q(\lambda,\lambda) = 0$ and $Q_p(\lambda,\lambda) = 0$. In addition, we have:

$$Q_{pp}(\lambda,p) = h''(\lambda)h''(p)\cdot\left[(\lambda-p)+2\cdot\left(\frac{h'(\lambda)}{h''(\lambda)}-\frac{h'(p)}{h''(p)}\right)\right]. \tag{31}$$

For $p < \lambda$, $\frac{h'(\lambda)}{h''(\lambda)} > \frac{h'(p)}{h''(p)}$ by the log-concavity of $h'(\cdot)$, implying that $Q_{pp}(\cdot) > 0$. In turn, this implies that $Q_p(\cdot) < 0$ for $p < \lambda$ and therefore that $Q(\cdot) > 0$ for $p < \lambda$. We thus have $[h(\lambda) - h(p)] \cdot Q(\lambda,p) > 0$.

For $p > \lambda$, a similar analysis of (31) using the log-concavity of $h'(\cdot)$ yields $Q_{pp}(\cdot) < 0$. This implies that $Q_p(\cdot) < 0$ for $p > \lambda$ and thus $Q(\cdot) < 0$ for $p > \lambda$. Again, we get $[h(\lambda) - h(p)]\cdot Q(\lambda,p) > 0$, thereby completing the proof of the first claim.

To prove decreasing differences in λ and δ, we find it convenient to let $p = -\delta$ and to rewrite (28) as:

$$ROI_T(\lambda,p) = \lambda + (p-\lambda)\cdot\left[\frac{h(\lambda)-h(r)}{h(\lambda)-h(p)}\right]. \tag{32}$$

We show that the cross-partial of (32) in λ and p is positive when the accounting is conservative (i.e., $p < r$). Simplifying the cross-partial and ignoring its (positive) denominator, we find that the sign of $\frac{\partial^2}{\partial\lambda\partial p}(ROI_T(\lambda,p))$ is given by the sign of:

$$F(\lambda,r,p) = [h(\lambda)-h(p)]\cdot\left[\begin{array}{c} h'(\lambda)\cdot[h(r)-h(p)]\cdot[h(\lambda)-h(p)-h'(p)(\lambda-p)] \\ +h'(p)\cdot[h(r)-h(\lambda)]\cdot[h(\lambda)-h(p)-h'(\lambda)(\lambda-p)] \end{array}\right]. \tag{33}$$

We must show that $F(\lambda,r,p) > 0$ for $p < r$. Note that if $p < r < \lambda$, then, by the monotonicity and convexity of the $h(\cdot)$ function, (33) immediately yields $F(\cdot) > 0$. Accordingly, we restrict attention to values of $\lambda < r$. Next, note that $F(\cdot)$ is symmetric in p and λ. With no loss of generality, we can thus assume that $p < \lambda < r$. Since $h(\cdot)$ is an increasing function, this implies that $0<[h(r) - h(\lambda)]<[h(r) - h(p)]$, or:

$$F(\lambda,r,p) > [h(\lambda)-h(p)]\cdot[h(r)-h(\lambda)]\cdot G(\lambda,p), \tag{34}$$

where $G(\lambda,p) = h'(\lambda)\cdot[h(\lambda)-h(p)-h'(p)(\lambda-p)] + h'(p)\cdot[h(\lambda)-h(p)-h'(\lambda)(\lambda-p)]$. It is thus sufficient for us to demonstrate that $G(\cdot)\geq 0$ for all values of $\lambda > p$. To do so, fix $\lambda > -1$ and consider the behavior of $G(\cdot)$ in p. First, note that $G(\lambda,-1) = h(\lambda)h'(\lambda) > 0$ and $G(\lambda,\lambda) = 0$. Moreover, $G_p(\lambda,\lambda) = G_{pp}(\lambda,\lambda) = 0$, while $G_{ppp}(\lambda,\lambda) = [h'(\lambda)h'''(\lambda) - 3h''(\lambda)^2] < 0$, by the log-concavity of $h'(\cdot)$. Together, these facts imply that $G(\cdot)$ is positive at small values of p and is tangent to the origin line from above as $p \to \lambda$. Finally, to verify that $G(\cdot)$ does not cut the origin line at any point prior to $p = \lambda$, we show that it cannot have a local maximum in this region. Suppose not, i.e., assume there exists $p^* < \lambda$ such that $G_p(\lambda,p^*) = 0$ and $G_{pp}(\lambda,p^*) \leq 0$. But, $G_p(\lambda,p^*) = 0$ implies:

$$h(\lambda) - h(p^*) - 2h'(\lambda)(\lambda-p^*) = \frac{h'(p^*)}{h''(p^*)}\cdot[h'(p^*) - h'(\lambda)]. \tag{35}$$

In turn, (35) indicates that:

$$G_{pp}(\lambda, p^*) = h'''(p^*) \cdot [h(\lambda) - h(p^*) - 2h'(\lambda)(\lambda - p^*)] + 3h''(p^*) \cdot [h'(\lambda) - h'(p^*)]$$
$$= \frac{(h'(\lambda) - h'(p^*))}{h''(p^*)} \cdot \left[3h''(p^*)^2 - h'(p^*)h'''(p^*)\right] > 0, \tag{36}$$

where the final inequality in (36) follows from $p^* < \lambda$, the convexity of $h(\cdot)$, and the log-concavity of $h'(\cdot)$. This contradicts the supposition that p^* is a local maximum, thus verifying that $G(\cdot) > 0$ for all $\lambda > p$. □

Proof of Corollary 3 To establish the limit results (i)–(iii), we note that the limit result for $\lambda \to -1$ is obvious. The result for $\lambda \to 0$ follows from repeated applications of l'Hospital's rule, as shown below:

$$\begin{aligned}\lim_{\lambda\to 0}\tfrac{\lambda}{T\cdot h(\lambda)-1} &= \lim_{\lambda\to 0}\tfrac{(1+\lambda)^T-1+\lambda T(1+\lambda)^{T-1}}{-T(1+\lambda)^{T-1}+T(1+\lambda)^T+\lambda T^2(1+\lambda)^{T-1}}\\ &= \lim_{\lambda\to 0}\tfrac{2(1+\lambda)+\lambda(T-1)}{-T+1+2T(1+\lambda)+\lambda T(T-1)}\\ &= \lim_{\lambda\to 0}\tfrac{2+\lambda+T\lambda}{1+T+T\lambda+\lambda T^2} = \tfrac{2}{1+T}.\end{aligned}$$

The limit result as $\lambda \to \infty$ follows from applying l'Hospital's rule once more to the final expression above.

Proof of Proposition 6 If a β-fraction of new investments is expensed, steady state depreciation is given by:

$$(1-\beta)\cdot b^o \cdot \frac{1}{T}\sum_{j=1}^{T}(1+\lambda)^{j-1} = (1-\beta)\cdot b^o \cdot \frac{1}{T}\frac{[(1+\lambda)^T - 1]}{\lambda}. \tag{37}$$

The starting book value is simply scaled by $(1-\beta)$, while cash flows and the specification of the internal rate of return (r) are unaltered. Income in the numerator of ROI_T is therefore given by:

$$c^o \cdot \left[\frac{(1+\lambda)^T - 1}{\lambda} - \beta(1+\lambda)^T\frac{[1-(1+r)^{-T}]}{r} - \frac{(1-\beta)[1-(1+r)^{-T}][(1+\lambda)^T - 1]}{T\lambda r}\right], \tag{38}$$

while book value in the denominator becomes:

$$\frac{1-\beta}{T}\cdot\frac{c^o[1-(1+r)^{-T}]}{r}\cdot\frac{[1-(1+\lambda)^T + \lambda T(1+\lambda)^T]}{\lambda^2}.$$

Simplification of the resulting ratio then yields $ROI_T(\lambda,0,\beta)$:

$$=\lambda\cdot\left[\frac{[(1+\lambda)^T-1][rT-1+(1+r)^{-T}]+\beta[1-(1+r)^{-T}][(1+\lambda)^T-1-\lambda T(1+\lambda)^T]}{(1-\beta)[1-(1+r)^{-T}][1-(1+\lambda)^T+\lambda T(1+\lambda)^T]}\right]$$

$$=\frac{\lambda\cdot[(1+\lambda)^T-1][1-(1+r)^T+rT(1+r)^T]+\beta[(1+r)^T-1][(1+\lambda)^T-1-\lambda T(1+\lambda)^T]}{(1-\beta)\cdot[(1+r)^T-1][1-(1+\lambda)^T+\lambda T(1+\lambda)^T]}$$

$$=\frac{\lambda\cdot[(1+\lambda)^T-1][1-(1+r)^T+rT(1+r)^T]}{[1-(1+\lambda)^T+\lambda T(1+\lambda)^T][(1+r)^T-1]}\cdot\frac{1}{1-\beta}-\frac{\lambda\cdot\beta}{1-\beta}$$

$$=\lambda\cdot\frac{[h(r)-\frac{1}{T}]}{[h(\lambda)-\frac{1}{T}]}\cdot\frac{1}{1-\beta}-\frac{\lambda\cdot\beta}{1-\beta}$$

$$=\frac{1}{1-\beta}\cdot[ROI_T(\lambda,0)-\lambda\cdot\beta].$$

The claim regarding the negative cross-partial derivative of $ROI_T(\lambda,0,\beta)$ follows immediately upon recalling that $ROI_T(\lambda,0)$ is everywhere decreasing in λ because setting $\delta = 0$ corresponds to conservative accounting.

Appendix B

Alternative methods for calculating the cost of capital

Method 1: Target Price Method (r_{DIV})

The target price method, introduced in Botosan and Plumlee (2002), employs a short-horizon form where the infinite series of future cash flows is truncated at the end of year five by inserting a forecasted terminal value. This yields the equation below. The primary assumption underlying this method is that analysts' forecasts of dividends per share during the forecast horizon and stock price at the end of the forecast horizon capture the market's expectation of those values.

$$P_0 = \sum_{t=1}^{5}(1 + r_{DIV})^{-t}(dps_t) + (1 + r_{DIV})^{-5}\cdot P_5$$

where:

- $P_0 =$ price at time $t = 0$.
- $P_5 =$ price at time $t = 5$.
- $r_{DIV} =$ estimated cost of equity capital.
- $dps_t =$ dividends per share.

Dividend forecasts for the current fiscal year (t = 1), the following fiscal year (t = 2), and the long run (t = 5), as well as maximum and minimum long-run target price estimates are collected from forecasts published by *Value Line* during the third quarter of the calendar year. Since *Value Line* does not provide dividend forecasts for years t = 3 and t = 4, we interpolate between the year t = 2 and t = 5 dividend forecasts using an implied straight-line rate of growth in dividends from year t = 2 to year t = 5.

Our forecast of terminal value (P_5) is the 25th percentile of *Value Line's* forecasted long-run price range, although our conclusions are robust to the use of the 50th percentile or the minimum value. We use the 25th percentile to adjust for an apparent optimistic bias in analysts' forecasts of target price. Current stock price (P_0) equals the stock price reported on *CRSP* on the *Value Line* publication date or closest date thereafter within 3 days of publication.

Method 2: Industry Method (r_{GLS})

The industry method, introduced by Gebhardt et al. (2001), employs a residual income valuation model derived from a 12-year forecast horizon. The following model results:

$$P_0 = b_0 + \sum_{t=1}^{11} \gamma_{GLS}^{t} \cdot (ROE_t - r_{GLS}) \cdot b_{t-1} + \frac{\gamma_{GLS}^{12}}{r_{GLS}} \cdot (ROE_{12} - r_{GLS}) \cdot b_{11}$$

where

- $ROE_t = \frac{eps_t}{b_{t-1}}$ is the forecasted return on equity for period t.
- eps_t = forecasted earnings per share in year t,
- b_t = book value per share in year t,
- r_{GLS} = estimated cost of equity capital,
- $\gamma_{GLS} \equiv \frac{1}{1+r_{GLS}}$.

Method 3: PEG Ratio Method (r_{PEG})

The PEG method, introduced by Easton (2004), proceeds as follows:

$$r_{PEG} = \sqrt{\frac{eps_2 - eps_1}{P_0}}.$$

Our method is similar, but we use long-run earnings forecasts (eps_5 and eps_4) in place of eps_2 and eps_1 (consistent with Botosan and Plumlee 2005). Accordingly, the empirical specification of the equation we employ to estimate r_{PEG} is given by:

$$r_{PEG} = \sqrt{\frac{eps_5 - eps_4}{P_0}}.$$

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