Financial Reporting, Growth, and Risk Premia

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1 Introduction

The link between accounting information and cost of equity capital is of fundamental interest to accounting academicians and regulators alike. A number of recent studies (e.g., Easley and O'Hara 2004 and Lambert et. al. 2007) examine the relationship between the quality of firms' disclosures and their costs of equity capital. A firm's cost of capital is equal to the risk-free interest rate plus a risk premium which depends on the investors' uncertainty about future cash flows. Since the conditional variance (or covariance) of a firm's future cash flows, and hence the risk premium, declines in the precision of information available to the investors, a central result in this literature is that cost of capital decreases in the quality of accounting information. Based on single period settings in which shareholders trade only once after release of information, these studies focus on the link between accounting information and the *ex-post* cost of capital. However, when shareholders are also allowed to trade prior to the public release of information, Christensen et al. (2010) find that the overall cost of capital remains unchanged in the precision of such information, since the reduction in the post-disclosure risk premium is precisely offset by the increase in the risk premium for the pre-disclosure period.

These pre- and post-disclosure effects of the release of public information will concurrently apply to each reporting period for an ongoing firm. Consequently, there is a need for examining the relationship between disclosure and periodic risk premia in a multiperiod setting.[1] This paper develops such a dynamic model of an infinitely lived firm owned by overlapping generations of investors. The overlapping generations model allows us to capture the notion that the the firm's life cycle exceeds the planning horizon of any single generation of finitely lived investors. A key focus of our analysis is to examine the effect of growth in the firm's cash flows on the relationship between financial reporting and the firm's cost of capital. To model growth, we assume that the firm has access to a technology that allows it to generate uncertain cash flows in each period, and the periodic cash flows depend on the history of overlapping investments undertaken by the firm. The firm's growth rate is measured by the change in the investment level in the current period relative to that in the previous period.

Each generation of risk-averse investors buys the firm from the previous generation and

[1]Christensen et al. (2010) comment "*However, in a truly multi-period context (in which empirical studies must be performed) it is less clear what will be the impact on period-by-period risk premia, since any interim period has elements of both preposterior and an ex-post risk premium.*"

sells it to the next generation at the end of their investment planning horizon. The shareholders expect to earn returns in the form of cash dividends and capital gains resulting from the sale of their shares to the investors of the next generation. The risk premium in each period is therefore determined by the sum of the premium that the investors demand for bearing the *dividend* risk and the premium associated with the resale *price* risk. In our CARA-Normal framework, the periodic risk premium is proportional to the variance of the terminal payoffs (i.e., dividends and resale price) of the current generation of investors.[2]

At the end of each period, the firm publicly releases an accounting statement that (i) reports its historical performance (i.e., the cash flows realized in the current period), and (ii) provides forward looking information about the cash flows to be realized in the next period. A more informative accounting system reduces the conditional variance of the forthcoming cash flows and hence lowers the risk premium demanded by the current shareholders for bearing the dividend risk. However, a more precise accounting disclosure also makes the resale price more volatile, which results in an increase in the risk premium associated with the price component of the shareholders' payoffs. Therefore the equilibrium relationship between disclosure quality and the periodic risk premia depends on the relative strengths of these two opposite effects. For instance, we find that the periodic risk premium decreases in the precision of accounting information for a steady state firm. Though periodic cash flows are equally risky for a steady state firm, the investors rationally assign less weight to the price risk due to discounting, since the resale price reflects the expected cash flows in future periods.

More generally, our analysis shows that the relationship between risk premium and accounting information depends on the firm's growth trajectory. Specifically, we find that when the firm is growing at a rate slower than the risk-free interest rate, a more informative accounting system results in lower risk premium. On the other hand, the risk premium *increases* in the precision of accounting information for a firm in relatively fast growth phase (i.e., when its growth rate exceeds the risk-free interest rate). As noted earlier, the periodic risk premium is determined by the sum of the dividend risk, which declines in the quality of accounting disclosures, and the price risk, which increases in the precision of accounting in-

[2]Since we model a single risky firm, any risk is systematic and priced as such. Our results readily extend to multi-asset economies as long as asset returns are correlated. In a multi-firm setting, Lambert et al. (2007) show that disclosure reduces not only the conditional variance of a firm's own cash flows, but also the conditional covariance with other firms' cash flows.

formation. For a fast growing firm, the cash flows for more distant future periods are riskier because they reflect the payoffs from the larger investments undertaken more recently. Since the price risk depends on the uncertainty associated with these more distant payoffs, the overall risk premium increases in the informativeness of the financial reporting system for a fast growing firm. On the other hand, the dividend risk is the dominant determinant of the overall risk premium for low growth firms, and the hence the risk premium decreases in accounting information for such firms. These results highlight that the relationship between cost of capital and quality of accounting disclosures crucially depends on a firm's growth trajectory. They also provide a potential explanation for the mixed empirical findings in this literature (e.g., Botosan and Plumlee 2002).

Our analysis demonstrates that a similar relationship between growth and risk premium holds when the investment payoffs are serially correlated. However, the threshold growth rate (above which the risk premium increases in the precision of accounting information) is higher than that when the cash flows are uncorrelated. In addition to varying with the forward-looking component of accounting information, the market price now also varies with the cash flows realized in the current period. Though higher quality disclosures increase the part of the price risk related to the forward-looking component of such disclosures, they also reduce the price variability due to uncertainty about the cash flows to be realized in the current period. As a consequence, the price risk is less sensitive to accounting information and the overall risk premium decreases in the precision of accounting information for a larger range of growth rates. The threshold growth rate monotonically increases in the degree of correlation among periodic cash flows. In the extreme case when the investment productivities follow a random walk, the risk premium decreases in the precision of accounting information irrespective of the growth rate.

The first part of our analysis focuses on a symmetric reporting regime in which the precision of accounting disclosures does not depend on whether the underlying news is good or bad. We next examine an asymmetric financial reporting regime in which bad news must be disclosed on a more timely basis. Investment expenditures are initially capitalized as assets on the firm's balance sheet. At the interim date, the firm is required to mark-down the book value of any asset whose current fair value has declined below its carrying value. If the firm reports an asset write-down, it essentially reveals its one-period ahead cash flows to the market in the current period. On the other hand, when no asset write-down is recognized, the market can only infer that the next period's cash flows are sufficiently high so as not to trigger a write-down. Therefore the posterior variance of the firm's future cash flows is higher conditional on a good news report (no asset write-down) than that conditional on a bad news report (asset write-down).[3]

The informativeness of the accounting system decreases in the degree of *unconditional* conservatism. The reason is that the firm provides forward-looking information only when there is an asset write-down, which is less likely if the assets' initial book values are relatively small; i.e., unconditional conservatism is relatively high.[4] Under asymmetric financial reporting, the periodic risk premium can be decomposed into: (i) an *informational* component, which is the risk premium under a hypothetical reporting policy that is equally informative but symmetric, and (ii) an *asymmetric* reporting component. We find that the asymmetric reporting component of the overall risk premium is always negative. Therefore, consistent with Suijs (2008), the overall risk premium is lower under a conditionally conservative reporting rule than under an equally informative symmetric reporting policy. Consistent with our finding in the symmetric reporting setting, the informational component of the periodic risk premium increases (decreases) in the degree of accounting conservatism for low (high) growth firms.

Though the relationship between the overall risk premium and accounting conservatism is generally ambiguous, we demonstrate that the informational component of the risk premium dominates when the degree of risk aversion is sufficiently small. An interesting implication is that, among the subset of high growth firms, the firms with more conservative accounting will simultaneously have high price-to-book ratios and low expected risk premia (i.e., low expected returns). This result provides a potential explanation for the value premium observed in stock returns. More generally, this analysis highlights that cross-sectional differences in accounting rules and growth rates can explain at least a part of the cross-sectional variation in expected returns.

We find that different generations of investors have divergent preferences for the quality and type of accounting information. The original owners of the firm prefer accounting

[3] In our model, conditional conservatism manifests through a direct application of the lower-of-cost-or-market asset valuation rule and implies that low reports are more informative than high reports. However, we note that an alternative definition of conditional conservatism, which requires that good news reports are more informative than bad news reports, has also been used in the literature (e.g., Gigler et al. 2009).

[4] See Beaver and Ryan (2005) for an analysis of the interaction between conditional and unconditional forms of accounting conservatism.

disclosure policies that reduce the total risk premium as measured by the discounted sum of periodic risk premia. As a consequence, their welfare improves with more precise and conditionally conservative disclosure policies. In contrast, the expected utilities of each subsequent generation *increase* in the periodic risk premium during that generation's investment horizon.[5] Consequently, these investors are made worse-off with conditionally conservative reporting policies and their preferences for the amount of public information depend on growth during their investment horizons. The net impact of accounting information on total social welfare will generally depend on how one weighs the utilities of different generations in the overall social welfare function. However, this analysis makes clear that cost of capital is generally not an appropriate summary metric to compare the welfare implications of alternative financial reporting policies.

In terms of the basic modeling framework, our paper is related to the asset pricing literature based on infinite horizon overlapping generations models with the CARA-Normal structure (e.g., Spiegel 1998). In the accounting literature, Suijs (2008) uses a similar overlapping generations model to investigate the effect of conditional conservatism on the ex-ante market price of the firm. Unlike our paper, however, Suijs (2008) does not characterize how the quality of accounting information affects periodic risk premia and welfare of different generations of investors. Our model with overlapping investments allows us to examine how these relationships depend on the firm's growth rate. Moreover, our information structure enables us to examine the interaction between conditional and unconditional conservatism and its effects on the relationships among variables such as price-to-book ratios and risk premia.

A number of papers (e.g., Christensen et al. 2010, Easley and O'Hara 2004, Hughes et al. 2007, Lambert et al. 2007) investigate the relationship between accounting disclosures and cost of capital. However, these papers model static single-period settings, and hence do not investigate how growth affects the link between accounting information and risk premium, which is a key focus of our dynamic analysis. Dye (1990) examines the effects of mandatory and voluntary disclosures on welfare of the firm's existing shareholders and the investors who buy from them in a two-period overlapping generations model. Gao (2010) employs a similar two-period model to evaluate the link between accounting information and cost of

[5] This is a consequence of the observation that investors generally prefer access to riskier assets, since they can earn more surplus for bearing risks associated with these assets. See Dye (1990), Gao (2010), and Kurlat and Veldkamp (2013) for similar results.

capital in a production setting. Beyer (2012) examines the effects of conditional conservatism and aggregation on the cost of equity capital and debt contracts in a two-period production setting.

The rest of the paper is organized as follows. Section 2 describes the basic setting. Section 3 develops a model of symmetric financial reporting and characterizes the relationship between the precision of accounting information and risk premium when periodic cash flows are independent as well as when they are serially correlated. Section 4 considers an asymmetric financial reporting setting and investigates how the degree of accounting conservatism affects periodic risk premia and price-to-book ratios. Section 5 concludes the paper.

2 Model Setup

We consider an economy where shares of a single risky firm and a risk-free asset are traded among overlapping generations of identical risk-averse investors. While the firm is an infinitely lived entity, investors live only for a finite time. Specifically, generation t investors buy the shares of the firm from the previous generation at date $t-1$ and sell them to the next generation at date t. The investors of each generation have homogenous prior beliefs and symmetric information about the firm's future cash flows. The firm's shares are traded in a perfectly competitive market. The supply of the firm's shares is normalized to one. We assume that the risk-free asset is in unlimited supply and yields a rate of return of $r > 0$. Let $\gamma \equiv \frac{1}{1+r}$ be the corresponding risk-free discount factor.

The firm undertakes a sequence of overlapping projects each with a useful life of two periods. Specifically, we assume that an investment of I_t dollars at date t generates uncertain cash flows of X_{t+2} dollars at date $t+2$.[6] Therefore, during each period, the firm has two projects in progress: one that will deliver cash flows at the end of the current period, and one that will deliver cash flows at the end of the next period. Since our primary objective is to investigate the relationship between investment growth and expected returns, the firm's investment policy $(I_1, I_2, \ldots)$ is exogenous to the model and assumed to be common knowledge to all investors. To ensure that the firm does not grow without bound and the expected firm price remains finite, we assume that the investment level is asymptotically

[6] Our results remain unchanged if the project undertaken at date t delivers cash flows at the interim date (date $t+1$) as well.

bounded from above by some $\bar{I}$.

Investment projects generate cash flows according to the following structure:

$$X_t = I_{t-2} \cdot x_t,$$

where x_t is a random variable representing the investment productivity parameter in period t. After period t cash flows are realized, the firm invests I_t in the new project that will generates payoffs in period $t+2$. We assume that the firm does not retain any cash and hence $X_t - I_t$ is distributed as dividends to the firm's current shareholders. We interpret $X_t - I_t$ as *net* dividends (i.e., dividends in excess of capital contributions) and allow them to be negative. The assumption that the firm does not carry any cash or financial asset is without loss of generality, since dividend policy is irrelevant in our symmetric information setting with unlimited and equal access to borrowing and lending at the risk-free rate.

At the end of period t, the firm publicly releases an accounting statement that (i) reports the firm's historical performance; i.e., the realized cash flow in the current period X_t, and (ii) conveys (potentially imperfect) information about the cash flows to be realized in the next period, X_{t+1}. The forward looking component of the accounting report is denoted by (signal) S_t, and the informativeness of the accounting system refers to the extent to which S_t reveals X_{t+1}. Specifically, we assume that

$$S_t \equiv I_{t-1} \cdot s_t,$$

where s_t is a signal of the investment productivity parameter in the next period, x_{t+1}. We delay a more detailed specification of the information structure (e.g., the correlation between s_t and x_{t+1}) to the next section. Subsequent to the firm's public release of the accounting report, (X_t, S_t), the market for the firm's shares opens and the current shareholders sell their stock to the investors of next generation.

In period t, the sequence of events is as follows:

- Cash flows (from the project started two periods ago) X_t are realized.
- The investment in the new project, I_t, is made.
- The current shareholders (i.e., generation t) receive a net dividend of $X_t - I_t$.

- The accounting report (X_t, S_t) is released to the market.

- The market for the firm's shares opens, and the firm is sold to the investors of next generation (i.e., generation $t+1$).

- The investors of generation t consume their terminal wealth.

As the timeline above makes clear, the price that generation $t+1$ investors are willing to pay to buy the firm from the previous generation reflects their beliefs about the cash flows that the project in progress will deliver at date $t+1$ (conditional on the accounting report S_t), the amount of cash needed for the next period's investment, as well the price at which the firm can be resold at date $t+1$ to the next generation.

Each generation consists of a continuum of investors (with unit mass) who act as price takers in the stock market. Since investors are identical and have symmetric information, it is without loss of generality to represent each generation by a single representative investor. The representative investor of generation t seeks to maximize the expected utility of his consumption at the end of period t, c_t. For each $t = 1, 2, \ldots$, the expected utility takes the following mean-variance form:

$$EU_t\left(c_t\right) = E_{t-1}\left(c_t\right) - \frac{1}{2} \cdot \rho \cdot Var_{t-1}\left(c_t\right), \tag{1}$$

where c_t denotes the investor's consumption (terminal wealth) at date t, ρ is the coefficient of risk aversion, and $E_{t-1}\left(\cdot\right)$ and $Var_{t-1}\left(\cdot\right)$ denote the expectation and variance operators conditional on the information available at date $t-1$ (i.e., the beginning of period t). The next section considers a setting in which the investment payoffs and the related accounting variables are jointly normally distributed. Therefore, conditional on the information available at date $t-1$, the representative investor's date t consumption c_t is also normally distributed. In this setting, the reduced form of preferences in (1) is equivalent to the assumption that the investor possesses negative exponential utility with coefficient of constant absolute risk aversion CARA ρ; i.e., $U_t(c_t) = -exp[-\rho \cdot c_t]$.

3 Accounting Information and Risk Premia

A number of recent accounting studies (e.g., Christensen et al. 2010) investigate the link between information and expected returns (i.e., risk premium) in the class of models in which risky assets' payoffs and the related informational signals are normally distributed. Following this literature, this section examines a setting in which the investment payoffs, and the corresponding accounting reports, are jointly normally distributed.[7] While the earlier papers in this area study static models, we study the relationship between accounting information and risk premium in a dynamic setting with overlapping investments and overlapping generations of investors. We allow for more general distributions of cash flows and explicitly model asymmetric financial reporting policies in Section 4.

3.1 Independent Cash Flows

In this subsection, we examine a setting in which the periodic investment payoffs are independently distributed. To model normally distributed cash flows, suppose that the investment productivity parameters, x_t are drawn from a time-invariant normal distribution with mean m (with $m > 1$) and variance σ^2. To examine the case of independent cash flows, we assume that the investment productivities x_t are serially uncorrelated. The scaled accounting signal, s_t, measures the investment productivity in period $t + 1$ with noise:

$$s_t = x_{t+1} + \eta_t.$$

The noise terms η_t are serially uncorrelated and drawn from identical normal distributions with mean zero and variance σ_η^2. Under this formulation, we note that the informativeness of the accounting system is simply given by $\frac{1}{\sigma_\eta^2}$, the precision of s_t.

Let $\phi_t \equiv (X_t, S_t)$ denote the accounting information that is publicly released at date t. From the perspective of predicting the distributions of future cash flows, the current accounting signal S_t is a sufficient statistics for the entire history of information $(\phi_1, \ldots, \phi_t)$ available at date t, since the investment payoffs X_t and accounting signals S_t are both serially uncorrelated.

[7]This formulation is also consistent with much of the work in the noisy rational expectation literature (e.g, Kyle 1985 and Grossman and Stigliz 1980) as well as the overlapping generations models of asset pricing in the CARA-Normal framework (e.g., Spiegel 1998).

Our primary objective is to examine how accounting information and investment growth impact on the risk premium that the rational investors demand for holding the firm. To formally define the risk premium, let P_t denote the price of the firm at date t. Generation $t+1$ buys the firm at price P_t , gets a net dividend of $X_{t+1} - I_{t+1}$, and sell the firm at price P_{t+1} to the next generation. The *ex-post* risk premium in period $t+1$ can then be written as:

$$RP_{t+1}(S_t) = E_t[X_{t+1} - I_{t+1} + P_{t+1}] - (1+r) \cdot P_t.$$

The *ex-ante* risk premium RP_{t+1} is defined as the expectation over S_t of the ex-post risk premium; i.e., $RP_{t+1} = E\left[RP_{t+1}(S_t)\right]$. For brevity, in the remainder of the paper, we refer to the ex-ante risk premium as simply the risk premium.[8]

Before presenting an explicit expression for the risk premium, it will be useful to develop some additional notation. Let

$$\sigma_p^2 \equiv Var_t(x_{t+1}) = Var(x_{t+1}|s_t)$$

denote the posterior variance of x_{t+1}. It can be easily checked that $\sigma_p^2 = k \cdot \sigma_\eta^2$, where $k \equiv \frac{\sigma^2}{\sigma^2+\sigma_\eta^2}$. The posterior variance of x_{t+1} does not depend on the realization of s_t, which is a well-known property of the normal distribution. We also note that conditional on date t information s_t, the posterior mean of x_{t+1} is given by $E_t(x_{t+1}) = (1-k) \cdot m + k \cdot s_t$. From an ex-ante perspective, this posterior mean is a normally distributed random variable with variance σ_a^2, where

$$\sigma_a^2 \equiv Var_{t-1}[E_t(x_{t+1})].$$

It is easily verified that $\sigma_a^2 = k \cdot \sigma^2$, and the law of total variance holds; i.e.,

$$\sigma_a^2 + \sigma_p^2 = \sigma^2.$$

As expected, σ_p^2 decreases in the precision of accounting information (i.e., $\frac{1}{\sigma_\eta^2}$), while σ_a^2 increases as accounting information becomes more precise. Therefore we will sometimes use

[8]We note that $RP_{t+1}(S_t)$ does not depend on the realized value of S_t for the case of normally distributed cash flows, and hence the ex-ante and ex-post measures of risk premium are identical for the normal case. We provide this definition for more general distributions used in connection with asymmetric financial reporting in Section 4.

the magnitude of σ_a^2 as a measure of the informativeness of the accounting system.[9]

Lemma 1. *Assume that X_t and S_t are jointly normally distributed for all t. The risk premium in period $t+1$ is given by:*

$$RP_{t+1} = \rho \cdot \left(I_{t-1}^2 \cdot \sigma_p^2 + \gamma^2 \cdot I_t^2 \cdot \sigma_a^2\right) \tag{2}$$

for all t.

When the investors of the current generation buy the firm's stock at date t, they expect to receive two different forms of payoffs at date $t+1$: (i) the dividends in the amount of $X_{t+1} - I_{t+1}$, and (ii) P_{t+1}, the price at which they sell their shares to the next generation. We note that both of these payoffs are uncertain from the perspective of date t. While the first term on the right-hand side of (2) reflects the risk premium that the investors earn for bearing the *dividend* risk, the second term captures the risk premium associated with the resale *price* component of the payoffs.[10]

To provide further intuition for these two components, we note that a standard result for mean-variance preferences of the form in (1) is that the equilibrium price for uncertain payoff y is given by $p = \gamma \cdot [E(y) - \rho \cdot Var(y)]$.[11] Thus date t market price must satisfy the following equilibrium condition:

$$P_t = \gamma \cdot \left[E_t(X_{t+1} - I_{t+1} + P_{t+1}) - \rho \cdot Var_t(X_{t+1} + P_{t+1})\right].$$

This implies that the equilibrium amount of risk premium earned by generation $t+1$ investors is given by the term $\rho \cdot Var_t(X_{t+1} + P_{t+1})$. As expected, the risk premium increases in the risk aversion parameter ρ and the variability of the payoffs. Since investment payoffs are serially uncorrelated, the cash flows in period $t+1$, X_{t+1}, are uncorrelated with the one-period ahead

[9]For instance, if the accounting reports are perfectly informative about the next period cash flows (i.e., $\sigma_\eta^2 = 0$), then the conditional variance of these cash flows is zero (i.e., $\sigma_p^2 = 0$), while σ_a^2 is equal to σ^2 because $E_t(x_{t+1})$ is simply x_{t+1}. At the other extreme, when the accounting reports are entirely uninformative, the posterior variance of the one-period-ahead cash flows remains the same as the prior variance (i.e., $\sigma_p^2 = \sigma^2$), while $\sigma_a^2 = 0$ because date $E_t(x_{t+1})$ is simply equal to the non-stochastic prior mean of x_{t+1}.

[10]Since our model has a single risky asset, any risk is systematic and is priced as such. However, our results can be readily extended to a multi-asset economy as long as asset returns are correlated. See Hughes et al. (2007) and Lambert et al. (2007) for analysis of the relationship between risk premium and information in single period models with mutltiple assets.

[11]See the proof of Lemma 1 in the Appendix for a formal argument.

market price, P_{t+1}. The expression for the risk premium can thus be written as:

$$RP_{t+1} = \rho \cdot Var_t(X_{t+1}) + \rho \cdot Var_t(P_{t+1}).$$

That is, the equilibrium risk premium, RP_{t+1}, is the sum of the investors' compensation for bearing (i) the *dividend* risk as measured by $Var_t(X_{t+1}) = I_{t-1}^2 \cdot \sigma_p^2$, and (ii) the resale *price* risk as measured by $Var_t(P_{t+1})$.

To calculate $Var_t(P_{t+1})$, we note that P_{t+1} must satisfy the market clearing condition:

$$P_{t+1} = \gamma \cdot \left[E_{t+1}(X_{t+2} + P_{t+2} - I_{t+2}) - \rho \cdot Var_{t+1}(X_{t+2} + P_{t+2})\right].$$

Since period $t+1$ accounting information s_{t+1} is uncorrelated with the one-period-ahead market price P_{t+2}, date $t+1$ expectation of the price, $E_{t+1}(P_{t+2})$, is non-stochastic. Since the conditional variance for bivariate normal distributions does not depend on the conditioning variable, $Var_{t+1}(X_{t+2} + P_{t+2})$ is also non-stochastic.[12] It thus follows that:

$$Var_t(P_{t+1}) = \gamma^2 \cdot Var_t\left[E_{t+1}(X_{t+2})\right] = \gamma^2 \cdot I_t^2 \cdot \sigma_a^2. \tag{3}$$

To summarize, equation (2) demonstrates that the investors buying the firm at date t are exposed: (i) to the uncertainty of the payoffs from project I_{t-1}, since these payoffs directly affect their dividends, and (ii) to the uncertainty of the payoff from project I_t indirectly through these payoffs' effect on the firm's resale price at date $t+1$. The risk premium term corresponding to project I_t is discounted by γ^2 because P_{t+1} reflects the (one-period) discounted value of X_{t+2}, and the risk premium is proportional to the variance in our mean-variance framework.

To formulate our first proposition, let μ_t denote the investment growth rate in period t; i.e.,

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

Proposition 1. *Assume that cash flows and the corresponding accounting signals are jointly normally distributed. The risk premium in period $t+1$ decreases (increases) in the informativeness of the accounting system if $\mu_t < r$ ($\mu_t > r$).*

[12] We confirm in the Appendix that the equilibrium market price P_t is a linear function of the current accounting signal s_t, and hence normally distributed. Therefore X_{t+2} and P_{t+2} are both normal from the perspective of date $t+1$.

This result highlights that the equilibrium relationship between risk premium and accounting information depends on the firm's growth trajectory. When investments are growing relatively slowly (i.e., $\mu_t < r$), a more informative accounting system results in lower risk premium. On the other hand, the risk premium *increases* in the precision of accounting information for firms in relatively fast growth phase (i.e., $\mu_t > r$).

To explain the intuition for this result, we recall that investors of each generation are subject to a dividend risk, which is proportional to $Var_t(x_{t+1}) \equiv \sigma_p^2$, and a (resale) price risk, as measured by $Var_t[E_{t+1}(x_{t+2})] \equiv \sigma_a^2$. While a more informative accounting system reduces the dividend risk, it also makes the resale price more volatile by increasing σ_a^2. By the law of total variance, $\sigma_p^2 + \sigma_a^2 = \sigma^2$, and hence the risk premium in period $t+1$ can be written as:

$$RP_{t+1} = \rho \cdot [I_{t-1}^2 \cdot \sigma^2 + (\gamma^2 \cdot I_t^2 - I_{t-1}^2) \cdot \sigma_a^2].$$

Therefore, the net effect of accounting information on the overall risk premium depends on the weights assigned to the dividend and price risk components (i.e., I_{t-1} and $\gamma \cdot I_t$, respectively). For a fast growing firms, the investors rationally assign more weight to the price risk; that is the risk associated with payoffs from the more recent project I_t. As a result, the overall risk premium for a fast growing firm increases in the precision of accounting information. On the other hand, the dividend risk is the dominant determinant of the overall risk premium for low growth firms (i.e., the firms for which $\gamma \cdot I_t < I_{t-1}$), and hence the risk premium decreases in the informativeness of the accounting system for such firms.

Christensen et al. (2010) and Lambert et al. (2007) also investigate the link between accounting information and risk premium in symmetric information settings within the class of Normal-CARA models. In a single period setting with public disclosure, Lambert et al. (2007) show that the risk premium subsequent to public disclosure decreases in the precision of that disclosure. Christensen et al. (2010) consider a setting in which the investors can trade before, as well as after, public disclosure. They find that the reduction in the ex-post risk premium following a more informative disclosure is precisely offset by the increase in the risk premium for the period before disclosure. As a consequence, the overall risk premium covering the entire (two-period) horizon of the firm remains unchanged. The investors in the model of Christensen et al. (2010) are subject to the posterior variance of the terminal dividend in the period subsequent to the release of public disclosure and to the price risk (referred to as the *preposterior* risk) in the period prior to public disclosure. While a more informative public disclosure reduces the posterior risk premium, the law of total variance implies that the preposterior risk premium increases by the offsetting amount, and hence the overall risk premium is independent of the public report.

In contrast to the above result, our analysis shows that the risk premium generally varies with the precision of accounting information. It can be readily verified that the overall risk premium decreases in the quality of accounting information even when our overlapping generations model is reduced to a two-period setting with a single terminal payoff (which corresponds to the setting in Christensen et al 2010) as long as the risk-free rate r is non-zero. This difference in the results arises from different assumptions about the investors' planning horizons in the two papers. In Christensen et al. (2010), the investors care only about the uncertainty of the terminal payoff (but not the intermediate price), since they can hold the firm for its entire duration of two periods. In our overlapping generations model, however, the original shareholders are concerned about the risk associated with the intermediate price.

While the reduced risk premium (i.e, the cost of capital) is frequently used as a justification for more accounting disclosures, our analysis allows us to explicitly characterize the impact of accounting information on investors' equilibrium expected utilities. Surprisingly, the result below shows that investors' welfare and risk premium are *positively* associated.

Corollary 1. *The equilibrium expected utility of generation $t+1$ investors decreases (increases) in the informativeness of the accounting system if $\mu_t < r$ ($\mu_t > r$).*

Following a low (high) growth period, the representative investor's expected utility is maximized by the least (most) informative reporting system. At first glance, this result appears counter-intuitive. Combined with Proposition 1, this result implies that a lowering of the ex-ante risk premium *reduces* investors' welfare. Put differently, investors prefer to have access to riskier payoffs. To understand the intuition, note that the price of the firm must satisfy the following equilibrium condition:

$$P_t = \gamma \cdot [E_t(Y_{t+1}) - \rho \cdot Var_t(Y_{t+1})],$$

where $Y_{t+1} \equiv X_{t+1} - I_{t+1} + P_{t+1}$ denotes the firm's cum-dividend price at date $t+1$. The investor's expected utility is given by:

$$EU_t = E_t[Y_{t+1} - (1+r) \cdot P_t] - \frac{\rho}{2} \cdot Var_t(Y_{t+1}). \tag{4}$$

As $Var_t(Y_{t+1})$ increases by one unit, the investor's consumption becomes more risky and the equilibrium price drops by $\gamma \cdot \rho$ units. This implies that the expected return of holding the risky asset, $E_t[Y_{t+1} - (1+r) \cdot P_t]$, increases by $\rho \cdot \gamma \cdot (1+r) = \rho$ units. This is the indirect effect of increased variance on the investor's expected utility as given by the first term on the right-hand side of (4). An increase of one unit of variance also has the direct effect, as captured by the second term on the right hand side of (4), of reducing the investor's expected utility by $\frac{\rho}{2}$ units. In the mean-variance framework, therefore, the indirect effect of increased expected returns dominates and the investor's expected utility is increasing in $Var_t(Y_{t+1})$ and hence in the risk premium.[13] The result then follows from Proposition 1.

Corollary 1 implies that, in our overlapping generations model, the impact of accounting information on total social welfare will generally depend on how one weighs the utilities of different generations in the overall social welfare function. Moreover, we note that Corollary 1 characterizes the effect of accounting information on the welfare of each generation of investors, but not on the original owners of the firm. The original owners sell the firm to the first generation of investors at price P_0, which is given by the discounted sum of expected future cash flows net of periodic risk premia; i.e.,

$$P_0 = \sum_{t=1}^{\infty} \gamma^t \cdot [E_0(X_t) - I_t - RP_t].$$

The original owners' welfare is therefore maximized by the accounting disclosure policy that minimizes the *total* risk premium as measured by the discounted sum of periodic risk risk premia $\sum_{t=1}^{\infty} \gamma^t \cdot RP_t$. To see how the total risk premium varies with the precision of accounting information, note that accounting information S_t shifts some of the risk associated with period $t+1$ cash flows X_{t+1} from generation $t+1$ to generation t. For instance, relative to a policy of no disclosure, a policy of complete disclosure ($\sigma_\eta^2 = 0$) effectively advances the risk associated with each project by one period. Hence the present value of future periodic risk premia decreases in the informativeness of the accounting system.[14] Consequently, unlike the future generations of investors whose preferences for accounting information depend

[13]This intuition is based on a similar finding in Kurlat and Veldkamp (2013), who also argue that this result (i.e., investors prefer riskier payoffs) is likely to remain valid in settings beyond the Normal-CARA framework. See also Dye (1990) and Gao (2010) for similar results.

[14]To see this explicitly, note that the total risk premium can be expressed as $\sum_{t=1}^{\infty} \gamma^t \cdot I_{t-2}^2 \cdot (\sigma_p^2 + \gamma \cdot \sigma_a^2)$. It thus follows that the total risk premium decreases in the precision of accounting information, since $\sigma_p^2 + \gamma \cdot \sigma_a^2$ decreases in the informativeness of accounting for $\gamma < 1$.

on the firm's growth rate during their investment horizons, the original owners' welfare unambiguously increases in the precision of accounting information. This is consistent with Suijs (2008) who examines an overlapping generations model of a steady state firm and finds that more informative accounting disclosures lead to higher expected payoffs for the firm's original shareholders.

3.2 Correlated Cash Flows

We have thus far assumed that the firm's earnings (cash flows) are serially uncorrelated. In this subsection, we investigate an extension of our basic model in which the investment payoffs are positively correlated across periods. Specifically, suppose that the investment productivity parameters x_t evolve according to the following mean-reverting stochastic process with unconditional mean m (with $m > 1$):

$$x_t = w \cdot x_{t-1} + (1 - w) \cdot m + \varepsilon_t,$$

where w is a commonly known persistence parameter between zero and one. The innovation terms ε_t are serially uncorrelated and follow a joint normal distribution with mean zero and variance σ^2. The total gross cash flow in period t is again given by $I_{t-2} \cdot x_t$ and the accounting signal $S_t = I_{t-1} \cdot s_t$ provides information about period $t+1$ cash flows X_{t+1}. As before, s_t is a noisy measure of the investment productivity in the next period, x_{t+1}.

With uncorrelated cash flows, the current accounting signal s_t was sufficient for the entire history of information for the purpose of predicting future cash flows. In contrast, when cash flows are autocorrelated, the current cash flow parameter x_t also provides useful information for predicting future cash flows. With autocorrelated cash flows, the current accounting report $\phi_t = (x_t, s_t)$ constitutes a sufficient statistics for the history of information $(\phi_1, \ldots, \phi_t)$. It will be convenient to normalize the accounting signal to $\hat{s}_t = s_t - E[x_{t+1}|x_t]$. We note that $(x_t, \hat{s}_t)$ is informationally equivalent to (x_t, s_t) and

$$\hat{s}_t = \varepsilon_{t+1} + \eta_t.$$

It can then be easily checked that:

$$E_t[x_{t+\tau}] = w^\tau \cdot x_t + (1 - w^\tau) \cdot m + w^{\tau-1} \cdot E_t(\varepsilon_{t+1}), \tag{5}$$

where $E_t(\varepsilon_{t+1}) = k \cdot \hat{s}_t$ with $k = \frac{\sigma^2}{\sigma^2+\sigma_\eta^2}$.

Since cash flows are serially correlated, the realized value of cash flow in the current period is informative about all future cash flows. The parameter w reflects the relative persistence of the current cash flow news in predicting future cash flows. The case of $w = 0$ corresponds to the uncorrelated cash flow scenario examined earlier. In this case, the prediction equation in (5) simplifies to $E_t(x_{t+1}) = m + E_t(\varepsilon_{t+1})$ and $E_t(x_{t+\tau})$ is equal to the unconditional mean m for all $\tau \geq 2$. The other polar case of $w = 1$ represents the scenario in which the investment productivity parameters x_t follow a random walk.

As before, we note that the risk premium in period $t + 1$ is given by:

$$RP_{t+1} = \rho \cdot Var_t(X_{t+1} + P_{t+1}). \tag{6}$$

When the project payoffs are entirely transient (i.e., $w = 0$), the ex-dividend price P_{t+1} does not depend on the current cash flow information X_{t+1}, and hence X_{t+1} and P_{t+1} are independent. With autocorrelated cash flows, however, a higher value of cash flow in the current period raises the expectations of future cash flows, and hence X_{t+1} and price P_{t+1} are no longer independent. To understand how the price varies with the current cash flow news, we note from equation (5) that the present value of future expected cash flows, $\sum_{\tau=1}^{\infty} \gamma^\tau \cdot E_{t+1}(X_{t+\tau+1})$, increases in x_{t+1} at the rate of $\gamma \cdot w \cdot Q_t$, where

$$Q_t \equiv \sum_{\tau=0}^{\infty} (\gamma \dot{} w)^\tau \cdot I_{t+\tau}.$$

As expected, the "cash flow response coefficient" (i.e., $\gamma \cdot w \cdot Q_t$) is increasing in (i) the persistence parameter w which amplifies the impact of current cash flow news x_{t+1} on the expected values of future productivity parameters, and (ii) the future investment amounts. Similarly, equation (5) implies that the present value of expected future cash flows increases in $E_{t+1}(\varepsilon_{t+2})$ at the rate of $\gamma \cdot Q_t$. Consequently, the market price can be written as:

$$P_{t+1} = \gamma \cdot Q_t \cdot [w \cdot x_{t+1} + E_{t+1}(\varepsilon_{t+2})] + \alpha, \tag{7}$$

where α is some constant independent of the current information and $E_{t+1}(\varepsilon_{t+2}) = k \cdot \hat{s}_{t+1}$. Substituting the above in (6) and noting that $Var_t(x_{t+1}) = \sigma_p^2$ and $Var_t[E_{t+1}(\varepsilon_{t+2})] = \sigma_a^2$, we get that the risk premium in period $t+1$ is given by:

$$RP_{t+1} = \rho \cdot \left(Q_{t-1}^2 \cdot \sigma_p^2 + \gamma^2 \cdot Q_t^2 \cdot \sigma_a^2\right). \tag{8}$$

A comparison with the expression for the risk premium in the uncorrelated case reveals that I_{t-1} and I_t in (2) need to be replaced with Q_{t-1} and Q_t, respectively, to account for serial correlation in the project cash flows.

Proposition 2. *Suppose that the investment payoffs are autocorrelated. The risk premium in period $t+1$ decreases in the informativeness of the accounting system if $I_{t-1} > \gamma \cdot (1-w) \cdot Q_t$, and increases otherwise.*

An immediate implication of the above result is that if the productivity parameters follow a random walk (i.e., $w = 1$), the risk premium unambiguously decreases in the informativeness of the accounting report regardless of how investments vary over time. To understand the intuition, it is helpful to expand equation (6) as follows:

$$\rho^{-1} \cdot RP_{t+1} = Var_t(X_{t+1}) + Var_t(P_{t+1}) + 2 \cdot Cov_t(X_{t+1}, P_{t+1})$$

The first term on the right-hand-side of the above equation represents the dividend risk, the second term reflects the price risk, and the last term captures the effect of correlation between price and dividend on the overall risk premium. We note from (7) that the contemporaneous prices and dividends are positively correlated because both increase in the realized value of productivity parameter x_{t+1}. Therefore both the dividend risk and the correlation between price and dividend are decreasing in the precision of accounting information, since the posterior variance of x_{t+1} decreases in the informativeness of accounting reports. Using the expression for the price in (7), the price risk component can be written as:

$$\begin{aligned}\sigma_{price}^2 &= (\gamma \cdot Q_t)^2 \cdot [w^2 \cdot \sigma_p^2 + \sigma_a^2] \\ &= (\gamma \cdot Q_t)^2 \cdot [\sigma^2 - \sigma_p^2 \cdot (1 - w^2)],\end{aligned}$$

where the last equality follows from the law of total variance (i.e., $\sigma_p^2 + \sigma_a^2 = \sigma^2$). This shows that the price risk is independent of accounting information for the case when $w = 1$. This implies that when the productivity parameters x_t follow a random walk, the overall risk premium unambiguously decreases in the amount of accounting information.

To understand why the price risk does not vary with accounting information for $w = 1$, consider the policy of full disclosure; i.e., $\hat{s}_{t+1} = \varepsilon_{t+2}$ with probability one. Under full disclosure, $E_{t+1}(\varepsilon_{t+2}) = \varepsilon_{t+2}$ and the realized value of x_{t+1} becomes perfectly known to the investors at date t. From date t perspective, therefore, the resale price P_{t+1} in (7) is subject to only the risk associated with the innovation term ε_{t+2}. Under the policy of non-disclosure policy, we note that $E_{t+1}(\varepsilon_{t+2}) = 0$ and hence P_{t+1} is subject to only the risk associated with x_{t+1} (i.e., the innovation term ε_{t+1}). Since the innovation terms are identically distributed, the price risk remains unchanged at σ^2 in both cases. The same intuition applies for the intermediate disclosure policies.

For $w < 1$, while a more informative accounting disclosure policy results in a more volatile resale price (i.e., σ^2_{price} increases), it also leads to a lower level of dividend risk and a lower covariance between the dividend and price. Therefore, the relation between the risk premium and accounting information depends on the value of the persistence parameter w and the investment growth rates. Unlike the uncorrelated cash flows case, however, the link between risk premia and accounting information generally depends on all future growth rates.

To characterize how growth affects the relationship between accounting information and risk premium, we examine a setting in which the firm initially grows at a constant rate of μ until it achieves a steady state size at some future date T. That is, $I_t = (1 + \mu) \cdot I_{t-1}$ for $t \le T$ and $I_t = I_T$ for all $t > T$. In the steady state phase, Proposition 2 shows that the periodic risk premium unambiguously decreases in the quality of accounting information. The result below characterizes the relation between risk premia and accounting information during the firm's growth phase.

Proposition 3. *Suppose $w \in (0, 1)$ and the firm grows at a constant rate until it reaches a steady state size. Then there exists a $\mu^* \in \left(r, \frac{r+w}{1-w}\right)$ such that the periodic risk premium decreases (increases) in the precision of accounting information if the growth rate is less (more) than μ^*. Moreover, the threshold growth rate μ^* increases in the persistence parameter w and approaches infinity as $w \to 1$.*

When the project payoffs are serially uncorrelated (i.e., $w = 0$), the periodic risk premium decreases (increases) in accounting information if the current growth rate is below (above) the risk-free interest rate r. Proposition 3 shows that a similar relationship between growth and risk premium holds when project payoffs are autocorrelated. However, the threshold growth rate μ^* in the correlated case is higher than the one in the uncorrelated case (i.e., $\mu^* > r$).

To understand why, notice from equation (7) that the market price in the correlated case depends on the current cash flow news x_{t+1} as well as on the forward-looking information (through the term $E_{t+1}[\varepsilon_{t+2}]$). As before, the price variability related to the forward-looking competent of accounting information increases in the informativeness of the accounting system; i.e., the variance of $E_{t+1}(\varepsilon_{t+2})$ increases in the precision of accounting information. However, a more precise accounting disclosure also lowers the price variability due to the the uncertainty regarding the current period cash flow x_{t+1}. Therefore an increase in the precision of accounting information results in a more muted increase in the price risk relative to its corresponding impact on the dividend risk. Put differently, the price risk is less sensitive to accounting information when cash flows are autocorrelated than when they are not. As a consequence, the overall risk premium decreases in accounting information for a larger range of growth rates for firms with serially correlated cash flows.

The threshold growth rate μ^* increases in the persistence parameter w because the price risk becomes increasingly less sensitive to accounting information as w increases and periodic cash flows become more highly autocorrelated. As discussed before, in the extreme when investment cash flows follow a random walk (i.e., $w = 1$), the overall risk premium decreases in the precision of accounting information regardless of the growth rate (i.e., $\mu^* \to \infty$).

4 Asymmetric Financial Reporting and Risk Premia

In the previous section, our analysis focused on a symmetric financial reporting regime in which the firm was required to release information of the same precision irrespective of the underlying news; i.e., whether the underlying information signified good news or bad news with regard to the firm's future prospects. In practice, financial reporting policies are usually asymmetric in the sense that they call for differential recognition of good and bad news. For example, under GAAP, firms are often required to mark down the values of their assets when the current fair values of these assets have fallen below their historical costs. However, when assets have appreciated in values, firms are generally not allowed to mark-up their book values. In this section, we investigate the relationship between risk premium and accounting information when financial reporting policies are asymmetric in recognition of good and bad news.

To model an asymmetric reporting regime, we assume that the firm initially capitalizes a fraction $\lambda \in [0, 1]$ of each project's investment expenditures as an asset on its balance sheet. That is, the projects undertaken at date t are recorded in the firm's balance sheet at an initial book value of $\lambda \cdot I_t$. The remaining $(1 - \lambda)$ fraction of the investment expenditures is directly expensed as incurred and may reflect the expenditures in R&D and other activities that are not recognized as assets in the financial statements.[15] For notational simplicity, we assume that no depreciation expense is recognized in the first period of the asset's life. We note that $1 - \lambda$ represents the degree of *unconditional* conservatism of the financial reporting system.

An alternative and equivalent interpretation of λ is that the investment expenditures I_t are initially capitalized as an asset with a book value of I_t, and $1 - \lambda$ fraction of this amount is subsequently recognized as depreciation expense in the first period of the asset's life. Under either of these two interpretations, date $t + 1$ book value of the asset (prior to any write-down) is equal to $\lambda \cdot I_t$ and $1 - \lambda$ captures the extent of unconditional conservatism of the accounting system.

The investment productivity parameters x_t are drawn from identical and independent distributions. Specifically, the random parameter x_t is assumed to be drawn from a distribution $F(x_t)$ with positive density $f(x_t)$ over the interval $[\underline{x}, \bar{x}]$ with mean $m > 1$ and variance σ^2. We allow for the support of the distribution to be unbounded. The density function $f(\cdot)$ is assumed to be continuous and bounded from above. Though we allow for the possibility that the investment productivity parameters are normally distributed, we no longer impose this assumption.

Our primary focus in this section is on asymmetric financial reporting rules that call for more timely recognition of losses than gains (i.e., accounting rules that are *conditionally* conservative). To model this, we assume that the firm receives perfect information about its one-period ahead cash flows at the end of each period.[16] Thus, the realized value of X_{t+1}

[15]The capitalization factor λ can also be thought of as representing a verifiability threshold for recognition of investment expenditures as assets. For instance, suppose the accounting rules require that the amount of expenditures to be capitalized must be such that the likelihood of the asset's future benefits exceeding the capitalized amount is above some minimum threshold $1 - F(\lambda)$.

[16]Our results can be readily extended to a setting when the firm receives only an imperfect signal about

becomes privately known to the firm at date t. To introduce earlier recognition of bad news, we assume that the firm is required to write down the book value of this asset to its current fair value of X_{t+1} if, and only if, the asset's current fair value is less than the its carrying value of $\lambda \cdot I_{t-1}$. If X_{t+1} is greater than $\lambda \cdot I_{t-1}$, then the asset's book value remains unchanged at its initial value. Therefore, date t book value of the project undertaken at date $t-1$ is given by $\min\{\lambda \cdot I_{t-1}, X_{t+1}\}$. The firm's book value at date t is then given by:[17]

$$B_t = \min\{\lambda \cdot I_{t-1}, X_{t+1}\} + \lambda \cdot I_t.$$

Essentially, when the market observes a write-down, the fair value of the firm's one-period ahead cash flows becomes precisely known to the investors at date t. On the other hand, when no write-down is reported, the market only knows that the next period's cash flows are sufficiently high so as not to trigger a write-down (i.e., $X_{t+1} > \lambda \cdot I_{t-1}$). Consequently, the posterior variance of the cash flows conditional on a good news report (no write-down) is higher than that conditional on a bad news report (when there is a write down).

We will use

$$S_t = \min\{\lambda \cdot I_{t-1}, X_{t+1}\}$$

to denote the information that becomes publicly available at date t about the cash flows to be realized in the next period (i.e., X_{t+1}). Correspondingly, $s_t \equiv \min\{\lambda, x_{t+1}\}$ denotes the investors' date t information about the one-period ahead investment productivity x_{t+1}. When the firm releases bad news (i.e., $s_t = x_{t+1} < \lambda$), the investors have perfect information about x_{t+1}. Conditional on good news (i.e., $s_t = \lambda$), the investor's posterior beliefs about x_{t+1} are given by the following density function with support over $[\lambda, \bar{x}]$:

$$f(x_{t+1}|s_t = \lambda) = \frac{f(x_{t+1})}{1 - F(\lambda)},$$

where $f(\cdot)$ and $F(\cdot)$ denote the prior density and distribution functions, respectively.

With regard to the investors' preferences, we again assume that the investors of each generation are identical and their risk preferences are described by the linear mean-variance

future cash flows.

[17] This expression for the book value reflects the capitalization factor interpretation of λ. If $1-\lambda$ were interpreted as the depreciation factor for the first period of an asset's life, then the firm's book value would become $B_t = \min\{\lambda \cdot I_{t-1}, X_{t+1}\} + I_t$. Our results remain unchanged under this alternative formulation.

utility function in (1). We note that even if the periodic cash flows are normally distributed, the distributions of the accounting information variables S_t would no longer be normal because of conditional conservatism. Consequently, the reduced form of preferences in (1) can no longer be derived from a more primitive specification that the investors have CARA utility functions. One issue with the reduced form of linear mean-variance preferences is that they are not necessarily consistent with the notion of first-order stochastic dominance. To ensure first-order stochastic dominance, we require that:

$$[E(x|x > \lambda) - \rho \cdot Var(x|x > \lambda)] > \lambda.$$

The left-hand side of the above inequality represents the equilibrium price for a risky payoff x with conditional distribution truncated from below at $x = \lambda$. Thus the inequality ensures that the price of this risky asset exceeds the price of a certain payoff of λ, since the risky asset pays more than λ in each state of the world.

We now turn to calculating the ex-ante risk premium given the asymmetric financial reporting policy of the type described above. We recall from the analysis in the previous section that the risk premium implicit in price P_t is equal to the sum of the risk premia associated with the forthcoming dividends, X_{t+1}, and the resale price, P_{t+1}. The ex-ante risk premium associated with the dividend component of generation $t+1$ investors' payoffs is then given by:

$$\rho \cdot E_{t-1}\left[Var_t\left(X_{t+1}\right)\right], \tag{9}$$

where we note that $Var_t(X_{t+1}) = 0$ when $s_t < \lambda$ and $Var_t(X_{t+1}) = I_{t-1}^2 \cdot Var(x|x > \lambda)$ when $s_t = \lambda$.

To calculate the risk premium associated with the resale price of the firm's shares, P_{t+1}, we note that P_{t+1} must satisfy the following equilibrium condition:

$$P_{t+1} = \gamma \cdot \left[E_{t+1}\left(X_{t+2} - I_{t+2} + P_{t+2}\right) - \rho \cdot Var_{t+1}\left(X_{t+2} + P_{t+2}\right)\right].$$

Since period $t+1$ accounting information s_{t+1} is uncorrelated with the one-period-ahead market price P_{t+2}, we note that $E_{t+1}(P_{t+2})$ and $Var_{t+1}(P_{t+2})$ are both non-stochastic. From the perspective of date t, therefore, the risk premium associated with P_{t+1} is equal to:

$$\rho \cdot Var_t\left(P_{t+1}\right) = \rho \cdot \gamma^2 \cdot Var_t\left[E_{t+1}\left(X_{t+2}\right) - \rho \cdot Var_{t+1}\left(X_{t+2}\right)\right] \tag{10}$$

The total risk premium in period $t+1$ is then equal to the sum of the dividend and price risk premia as given by equations (9) and (10), respectively. Expanding equation (10), the overall risk premium can be written as $RP_{t+1} = IC_{t+1} + AC_{t+1}$, where:

$$IC_{t+1} \equiv \rho \cdot E_{t-1}\left[Var_t\left(X_{t+1}\right)\right] + \gamma^2 \cdot \rho \cdot Var_t\left[E_{t+1}\left(X_{t+2}\right)\right] \tag{11}$$

and

$$AC_{t+1} \equiv \rho^2 \cdot \gamma^2 \cdot \left\{\rho \cdot Var_t\left[Var_{t+1}\left(X_{t+2}\right)\right] - 2 \cdot Cov_t\left[E_{t+1}\left(X_{t+2}\right), Var_{t+1}\left(X_{t+2}\right)\right]\right\}. \tag{12}$$

We will refer to IC_{t+1} as the *informational* component and to AC_{t+1} as the *asymmetric* reporting component of the risk premium. The following lemma summarizes our observations up to this point.

Lemma 2. *Under an asymmetric financial reporting policy, the risk premium in period $t+1$ is given by:*

$$RP_{t+1} = IC_{t+1} + AC_{t+1}, \tag{13}$$

where IC_{t+1} and AC_{t+1} are as defined in (11) and (12), respectively.

Recall that under the normality assumption of the previous section, the variance of X_{t+2} conditional on S_{t+1} is constant, and, therefore, both terms of the asymmetric component in equation (12) are equal to zero. Intuitively, the reporting policies considered in the previous section are symmetric in the sense that the precision of the accounting signal does not depend on whether the underlying news is good or bad. In contrast, under conditionally conservative accounting, the posterior variance of X_{t+2} is equal to zero when news is bad (i.e., a write-down is observed), and is greater than zero when news is good (i.e., the cash flows are high enough so as not to trigger a write-down). Therefore, the variance of the conditional variance of X_{t+2} given S_{t+1} (the first term on the right-hand side of equation (12)) is greater than zero. Moreover, the second term in the right-hand side of equation (12) is positive for conditionally conservative accounting rules, since the posterior uncertainty about X_{t+2} is low (high) when the conditional expectation of X_{t+2} is low enough to (high enough not to) trigger a write-down.

The informational component given in equation (11), IC_{t+1}, reflects the risk premium associated with the posterior risk of the project in place, I_{t-1}, as well the the preposterior risk associated with the expected value of cash flows from the new project, I_t. As in the previous section, a more informative reporting policy results in lower posterior and higher preposterior uncertainty for each project. Therefore, IC_{t+1}, is determined by the investments I_t and I_{t-1} and the informativeness of the reporting policy.

Our next Proposition characterizes how these two components of the risk premium depend on the degree of accounting conservatism.

Proposition 4. *Assume that the reporting policy is asymmetric.*

i The informational component of the risk premium in period $t+1$, IC_{t+1}, increases (decreases) in unconditional conservatism if $\mu_t < r$ ($\mu_t > r$).

ii The asymmetric component of the risk premium, AC_{t+1}, is always (weakly) negative.

iii For sufficiently small values of ρ, the overall risk premium in period $t+1$, RP_{t+1}, increases (decreases) in unconditional conservatism if $\mu_t < r$ ($\mu_t > r$).

The first part above follows from the fact that the informativeness of the accounting system decreases in the degree of unconditional conservatism as measured by λ^{-1}. To see this, we note that the accounting system provides forward-looking information about the one-period ahead cash flows only if these cash flows are going to be below the asset's current book value. The accounting system becomes less informative as the degree of unconditional conservatism λ^{-1} increases because the likelihood of an asset write-down declines in the asset's initial initial book value.[18] Consistent with the result in Proposition 1, therefore the informational component of the overall risk premium decreases (increases) in the degree of accounting conservatism if $\mu_t < r$ ($\mu_t > r$). Part (iii) of Proposition 4 is a consequence of the observation that, for small values of ρ, the overall risk premium varies with accounting conservatism in the same manner as its informational component.

The second part of Proposition 4 implies that the asymmetric recognition policy of conditional conservatism *lowers* the overall risk premium (relative to what it would be under

[18]Beaver and Ryan (2005) characterizes the valuation and information implications of the interaction between unconditional and conditional forms of accounting conservatism.

an equally informative symmetric reporting policy). This result is consistent with the finding of Suijs (2008). An intuitive explanation for this result is that the equilibrium prices are less volatile under conditionally conservative reporting rules than under symmetric (or aggressive) reporting policies. This effect is captured by the second-term of the asymmetric reporting component in (12), which measures the covariance between the conditional expected value $E_{t+1}(X_{t+2})$ and the conditional variance $Var_{t+1}(X_{t+2})$. As discussed earlier in connection with Lemma 2, this term is negative because posterior expected values and variances are negatively correlated for conditionally conservative accounting rules. In contrast, these posterior means and variances would be uncorrelated for unbiased accounting and positively correlated for aggressive accounting.

As discussed in connection with Corollary 1, welfare of the investors of generation t increases in the ex-ante risk premium in that period for each $t \geq 1$. Since conditional conservatism has the effect of lowering the ex-ante risk premium, the investors of each generation are *worse-off* under a conditionally conservative financial reporting policy than under an equally informative symmetric reporting policy. In contrast, the expected utility of the firm's original owners increases in the ex-ante price of the firm P_0, which in turn decreases in the discounted sum of periodic risk premia $\sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot RP_{\tau}$. Consistent with Suijs (2008), therefore, we find that conditional conservatism improves the original shareholders' welfare.

Proposition 4 highlights that the degree of unconditional conservatism is an important determinant of periodic risk premia (and hence market prices), and the relationship between conservatism and risk premium depends on growth. In light of this result, it is interesting to investigate how accounting conservatism affects the relationship between price-to-book ratio and risk-premium. Let PB_t denote the price-to-book ratio calculated at date t:

$$PB_t = \frac{P_t}{B_t}.$$

Both the numerator and the denominator of the price-to-book ratio depend on the realization of the accounting signal, s_t. To ensure that this ratio can be properly defined for all states of the world, we assume that $\underline{x} = 0$.

Proposition 5. *For sufficiently small values of ρ, the expected price-to-book ratio, $E[PB_t]$, increases in the degree of unconditional conservatism.*

Proposition 5 shows that the expected price-to-book ratio increases in expectation for both high-growth and low-growth firms. We show in the proof of Lemma 2 that the equilibrium price is given by the expected value of future cash flows minus the discounted value of future risk premia. Unconditional accounting conservatism affects future risk premia, and therefore the market price at each date. The effect of conservatism on future risk premia is generally ambiguous because it depends on future investment growth rates and the risk aversion parameter ρ. However, unconditional conservatism also has a direct effect on the book value of the firm. We show that the direct "denominator" effect of accounting conservatism dominates the price effect for small values of ρ regardless of whether the firm's growth rate is above or below r.

Taken together, part (iii) of Proposition 4 and Proposition 5 provide a potential explanation for the value premium observed in stock returns. Specifically, for the subset of high growth firms, these results show that the firms with more conservative accounting will simultaneously have high price-to-book ratios and low expected risk premia (i.e., low expected returns). This suggests that at least a part of the value premium could be explained by differences in accounting policies across firms. However, we note that our results predict the opposite relation between price-to-book and risk premium for low growth firms. Without sorting on growth rates, therefore, our analysis predicts that the average relation between price-to-book ratio and stock returns will depend on the relative mix of high and low growth firms in the economy. If growth rates for a majority of firms exceeded the risk-free rate of interest, one would expect to find a negative association between price-to-book and expected returns. More generally, our analysis highlights that the underlying investment growth and accounting rules may be important in explaining the relation between price-to-book and stock returns.

5 Conclusion

This paper studies the relationship between accounting information and risk premium (cost of capital) in a dynamic setting with overlapping investments and overlapping generations of investors. Our analysis demonstrates that the relationship between a firm's cost of capital and quality of its accounting disclosures crucially depends on the firm's growth trajectory. We also find that serial correlation among periodic cash flows plays a critical role in determining the nature of this relationship. Moreover, our analysis characterizes how growth and accounting conservatism interact to influence the link between disclosure and cost of capital and between price-to-book ratios and stock returns. While we investigate a pure exchange setting, our modeling framework can be readily adapted to production economies. In future research, it will be interesting to examine how accounting disclosures affect cost of capital directly as well as indirectly through their effects on firms' internal investment decisions in such models.

Appendix

Proof of Lemma 1:

Let $Y_t \equiv X_t - I_t + P_t$ denote the payoff to generation t from holding the firm from date $t-1$ to date t and let ω_{t-1} be the initial wealth of generation t. If the representative investor buys an α-fraction of the firm at date $t-1$ and invests the remaining cash in the risk-less security, the investor's expected utility of consumption of his terminal wealth $c_t$is given by

$$E_{t-1}[c_t] - \frac{1}{2} \cdot \rho \cdot Var_{t-1}[c_t], \tag{14}$$

where

$$c_t = \alpha \cdot Y_t + (\omega_{t-1} - \alpha \cdot P_{t-1})(1+r).$$

Taking the price P_{t-1} as given, the investor chooses α to maximize his expected utility in (14). The optimal α is determined by the following first-order condition:

$$E_{t-1}[Y_t] - P_{t-1} \cdot (1+r) - \rho \cdot \alpha \cdot Var_{t-1}[Y_t] = 0.$$

Therefore, the market clearing price (corresponding to $\alpha = 1$) is given by

$$P_{t-1} = \gamma \cdot (E_{t-1}[Y_t] - \rho \cdot Var_{t-1}[Y_t]). \tag{15}$$

Let us consider the following price process:

$$P_t = \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot \left(E_t[X_{t+\tau} - I_{t+\tau}] - \rho \cdot Var_{t+\tau-1}[X_{t+\tau}] - \rho \cdot \gamma^2 \cdot Var_{t+\tau-1}[E_{t+\tau}[X_{t+\tau+1}]] \right). \tag{16}$$

Note that since $x_{t+\tau}$ and $s_{t+\tau-1}$ are jointly normally distributed for all τ and $x_{t+\tau}$ is independent of all random variables realized up to date $t+\tau-2$, both $Var_{t+\tau-1}[X_{t+\tau}]$ and $Var_{t+\tau-1}[E_{t+\tau}[X_{t+\tau+1}]]$ are both measurable at date t.

The price P_t given in equation (16) is independent of X_t for all t. Therefore,

$$Var_{t-1}[Y_t] = Var_{t-1}[X_t] + Var_{t-1}[P_t].$$

Note further that all terms in the right hand side of equation (16) are constant from the perspective of date $t-1$, except for the term

$$\gamma \cdot E_t\left[X_{t+1}\right],$$

which depends on the realization of S_t.[19] Thus, if prices are given by equation (16), we have:

$$Var_{t-1}\left[Y_t\right] = Var_{t-1}\left[X_t\right] + \gamma^2 \cdot Var_{t-1}\left[E_t\left[X_{t+1}\right]\right].$$

We can now verify that the market clearing condition (15) holds at all dates if the prices are given by equation (16) :

$$\begin{aligned}
P_{t-1} &= \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot \left(E_{t-1}\left[X_{t+\tau-1} - I_{t+\tau-1}\right] - \rho \cdot Var_{t+\tau-2}\left[X_{t+\tau-1}\right] - \rho \cdot \gamma^2 \cdot Var_{t+\tau-2}\left[E_{t+\tau-1}\left[X_{t+\tau}\right]\right]\right) \\
&= \gamma \cdot E_{t-1}\left[X_t - I_t\right] - \rho \cdot \gamma \cdot Var_{t-1}\left[X_t\right] - \rho \cdot \gamma^3 \cdot Var_{t-1}\left[E_t\left[X_{t+1}\right]\right] \\
&\quad + \gamma \cdot \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot \left(E_{t-1}\left[X_{t+\tau} - I_{t+\tau}\right] - \rho \cdot Var_{t+\tau-1}\left[X_{t+\tau}\right] - \rho \cdot \gamma^2 \cdot Var_{t+\tau-1}\left[E_{t+\tau}\left[X_{t+\tau+1}\right]\right]\right) \\
&= \gamma \cdot E_{t-1}\left[X_t - I_t + P_t\right] - \rho \cdot \gamma \cdot Var_{t-1}\left[Y_t\right] = \gamma \cdot \left(E_{t-1}\left[Y_t\right] - \rho \cdot Var_{t-1}\left[Y_t\right]\right).
\end{aligned}$$

To conclude the proof, note that

$$\begin{aligned}
RP_{t+1} &= E_t\left[Y_{t+1} - (1+r)\, P_t\right] = \rho \cdot Var_t\left[Y_{t+1}\right] \\
&= \rho \cdot \left(Var_t\left[X_{t+1}\right] + \gamma^2 \cdot Var_t\left[E_{t+1}\left[X_{t+2}\right]\right]\right),
\end{aligned}$$

where

$$Var_t\left[X_{t+1}\right] = I_{t-1}^2 \cdot \sigma_p^2$$

and

$$Var_t\left[E_{t+1}\left[X_{t+2}\right]\right] = I_t^2 \cdot \sigma_a^2.$$

□

Proof of Proposition 1:

By Lemma 1,

$$RP_{t+1} = \rho \cdot \left(I_{t-1}^2 \cdot \sigma_p^2 + \gamma^2 \cdot I_t^2 \cdot \sigma_a^2\right).$$

[19] Note that under the joint normality assumption, $\gamma \cdot \rho \cdot Var_t\left[X_{t+1}\right]$ is the same for all realizations of S_t, and, therefore, is a constant from the perspective of date $t-1$.

By the law of total variance,

$$\sigma_p^2 + \sigma_a^2 = \sigma^2.$$

Therefore, we have:

$$\begin{aligned} RP_{t+1} &= \rho \cdot \left(I_{t-1}^2 \cdot \sigma_p^2 + \gamma^2 \cdot I_t^2 \cdot \sigma_a^2 \right) \\ &= \rho \cdot I_{t-1}^2 \left(\sigma_p^2 + \gamma^2 \cdot (1+\mu_t)^2 \left(\sigma^2 - \sigma_p^2 \right) \right) \\ &= \rho I_{t-1}^2 \gamma^2 \left(1+\mu_t\right)^2 \sigma^2 + \rho \cdot I_{t-1}^2 \left(1 - \gamma^2 \cdot (1+\mu_t)^2 \right) \sigma_p^2. \end{aligned}$$

Note that the first term in the right-hand side of the equation above does not depend on the informativeness of the accounting system. Since the informativeness of the accounting system is inversely related to the posterior variance of cash flows (i.e., σ_p^2), the second term decreases (increases) in the informativeness of accounting signals if

$$\left(1 - \gamma^2 \cdot (1+\mu_t)^2 \right) > 0.$$

The latter condition is equivalent to $\mu_t < r$.

□

Proof of Corollary 1:

The equilibrium expected utility of generation t investor is given by:

$$EU_{t-1} = E_{t-1}[Y_t + (\omega_{t-1} - P_{t-1})(1+r)] - \frac{1}{2} \cdot \rho \cdot Var_{t-1}[Y_t]$$

where ω_{t-1} is the investor's initial endowment of wealth, $Y_t = X_t - I_t + P_t$ is the cum-dividend price of the firm at date t, and P_{t-1} is the ex-dividend price at date $t-1$. Equation (15) yields:

$$(1+r) \cdot P_{t-1} = E_{t-1}[Y_t] - \rho \cdot Var_{t-1}[Y_t].$$

Substituting this in the above expression for the investor's expected utility, we get

$$EU_{t-1} = \omega_{t-1} + \frac{1}{2} \cdot \rho \cdot Var_{t-1}[Y_t].$$

The proof of Lemma 1 shows that $RP_t = \rho \cdot Var_{t-1}[Y_t]$, and hence

$$EU_{t-1} = \omega_{t-1} + \frac{1}{2} \cdot RP_t.$$

It thus follows from Proposition 1 that generation t investor's expected utility decreases (increases) in the informativeness of the accounting report if $\mu < r (\mu_t > r)$.

$\square$

Proof of Proposition 2:

Step I:

We first prove that the market price of the firm as a function of date t information (x_t, s_t) is given by:

$$\begin{aligned} P_t &= \gamma \cdot Q_{t-1} \cdot [w \cdot (x_t - m) + k \cdot \hat{s}_t] + \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot [m \cdot I_{t+\tau-2} - I_{t+\tau}] \\ & \quad - \rho \cdot \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot \left[\sigma_p^2 \cdot Q_{t+\tau-2}^2 + \sigma_a^2 \cdot Q_{t+\tau-1}^2\right], \end{aligned} \tag{17}$$

where $k \equiv \frac{\sigma^2}{\sigma^2+\sigma_\eta^2}$ and $Q_t \equiv \sum_{\tau=0}^{\infty} (\gamma \cdot w)^{\tau} \cdot I_{t+\tau}$. We note that the price in (17) is finite for all t, since Q_t, $\sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot Q_t$, and $\sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot Q_t^2$ are all finite given our assumption that $I_t \leq \bar{I}$ for all t.

As before, the market price P_t must satisfy the following equilibrium condition:

$$P_t = \gamma \cdot (E_t[Y_{t+1}] - \rho \cdot Var_t[Y_{t+1}]), \tag{18}$$

where $Y_{t+1} = I_{t-1} \cdot x_{t+1} - I_{t+1} + P_{t+1}$. Equation (17) implies that:

$$P_{t+1} = \gamma \cdot Q_t \cdot [w \cdot (x_{t+1} - m) + k \cdot \hat{s}_{t+1}] + \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot [m \cdot I_{t+\tau-1} - I_{t+\tau+1}] - \Delta_{t+1},$$

where, for brevity, we define:

$$\Delta_{t+1} \equiv \rho \cdot \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot \left[\sigma_p^2 \cdot Q_{t+\tau-1}^2 + \sigma_a^2 \cdot Q_{t+\tau}^2\right].$$

Substituting for P_{t+1} from the above expression into the expression for Y_{t+1} yields:

$$\begin{aligned}
Y_{t+1} &= (I_{t-1} + \gamma \cdot w \cdot Q_t)x_{t+1} + \gamma \cdot k \cdot Q_t \cdot \hat{s}_{t+1} - m \cdot (\gamma \cdot w) \cdot Q_t \\
&\quad + \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot [m \cdot I_{t+\tau-1} - I_{t+\tau+1}] - I_{t+1} - \Delta_{t+1} \\
&= Q_{t_1} \cdot x_{t+1} + \gamma \cdot k \cdot Q_t \cdot \hat{s}_{t+1} - m \cdot (\gamma \cdot w) \cdot Q_t + \sum_{\tau=1}^{\infty} \gamma^{\tau-1} \cdot [m \cdot \gamma \cdot I_{t+\tau-1} - I_{t+\tau}] - \Delta_{t+1},
\end{aligned}$$

where we have used $Q_{t-1} = I_{t-1} + \gamma \cdot w \cdot Q_t$ to derive the second equality.

We recall that

$$x_{t+1} = w \cdot x_t + (1 - w) \cdot m + \varepsilon_{t+1},$$

where $\{\varepsilon_{t+1}\}$ are *iid* normal random variables and $\hat{s}_t = \varepsilon_{t+1} + \eta_t$ with $\eta_t \sim N(0, \sigma_\eta^2)$. Using the formula for the conditional expectations gives:

$$E[\varepsilon_{t+1} | \hat{s}_t] = k \cdot \hat{s}_t.$$

It thus follows that:

$$E_t[x_{t+1}] = w \cdot x_t + (1 - w) \cdot m + k \cdot \hat{s}_t.$$

Since $E_t[\hat{s}_{t+1}] = 0$, we get

$$\begin{aligned}
E_t[Y_{t+1}] &= Q_{t-1} \cdot [w \cdot (x_t - m) + k \cdot \hat{s}_t] + m \cdot (Q_{t-1} - \gamma \cdot w \cdot Q_t) \\
&\quad + \sum_{\tau=1}^{\infty} \gamma^{\tau-1} \cdot [m \cdot \gamma \cdot I_{t+\tau-1} - I_{t+\tau}] - \Delta_{t+1} \\
&= Q_{t-1} \cdot [w \cdot (x_t - m) + k \cdot \hat{s}_t] + \sum_{\tau=1}^{\infty} \gamma^{\tau-1} \cdot [m \cdot I_{t+\tau-2} - I_{t+\tau}] - \Delta_{t+1}, \quad (19)
\end{aligned}$$

where we have again used $Q_{t-1} = I_{t-1} + \gamma \cdot w \cdot Q_t$ to derive the second equality in (19).

We note that

$$Var_t[x_{t+1}] = Var[\varepsilon_{t+1} | \hat{s}_t] = \sigma_p^2$$

and

$$Var_t[k \cdot \hat{s}_{t+1}] = Var[k \cdot \hat{s}_{t+1}] = \sigma_a^2.$$

Since x_{t+1} and $\hat{s}_{t+1}$ are independent, it follows that:

$$Var_t[Y_{t+1}] = \sigma_p^2 \cdot Q_{t-1}^2 + \gamma^2 \cdot \sigma_a^2 \cdot Q_t^2. \tag{20}$$

Substituting for $E_t[Y_{t+1}]$ and $Var_t[Y_{t+1}]$ from equations (19-20) into the right hand side of equation (18) yield

$$\begin{aligned} \gamma \cdot [E_t(Y_{t+1}) - \rho \cdot Var_t(Y_{t+1})] &= \gamma \cdot Q_{t-1} \cdot [w \cdot x_t + k \cdot \hat{s}_t] + \sum_{\tau=1}^{\infty} \gamma^\tau \cdot [m \cdot I_{t+\tau-2} - I_{t+\tau}] \\ &\quad -\gamma \cdot \Delta_{t+1} - \gamma \cdot \rho \cdot [\sigma_p^2 \cdot Q_{t-1}^2 + \gamma^2 \cdot \sigma_a^2 \cdot Q_t^2]. \end{aligned}$$

Using the definition of Δ_{t+1}, it can be easily verified that:

$$\gamma \cdot \Delta_{t+1} + \gamma \cdot \rho \cdot [\sigma_p^2 \cdot Q_{t-1}^2 + \gamma^2 \cdot \sigma_a^2 \cdot Q_t^2] = \rho \cdot \sum_{\tau=1}^{\infty} \gamma^\tau \cdot \left[\sigma_p^2 \cdot Q_{t+\tau-2}^2 + \sigma_a^2 \cdot Q_{t+\tau-1}^2\right].$$

It thus follows from (17) that;

$$\gamma \cdot [E_t(Y_{t+1}) - \rho \cdot Var_t(Y_{t+1})] = P_t.$$

We have thus verified that the equilibrium condition in (18) holds for all t if the market price is given by (17).

Step II:

From the proof of Step I, the risk premium in period $t+1$ is given by:

$$\begin{aligned} RP_{t+1} &= E_t\left[Y_{t+1} - (1+r) \cdot P_t\right] \\ &= \rho \cdot Var_t[Y_{t+1}] \\ &= \rho \cdot \left[\sigma_p^2 \cdot Q_{t-1}^2 + \gamma^2 \cdot \ \sigma_a^2 \cdot Q_t^2\right]. \end{aligned}$$

From the law of total variance, we note that $\sigma^2 = \sigma_p^2 + \sigma_a^2$. Substituting this in the above expression, we get

$$RP_{t+1} = \rho \cdot \sigma^2 \cdot Q_{t-1}^2 + \rho \cdot \sigma_a^2 \cdot [\gamma^2 \cdot Q_t^2 - Q_{t-1}^2].$$

Since σ_a^2 increases in the informativeness of the accounting report, the risk premium decreases (increases) in the informativeness of accounting when $\gamma \cdot Q_t - Q_{t-1}$ is negative (positive). Using the fact that

$$Q_{t-1} = I_{t-1} + \gamma \cdot w \cdot Q_t,$$

we get

$$\gamma \cdot Q_t - Q_{t-1} = \gamma \cdot (1 - w) \cdot Q_t - I_{t-1}. \tag{21}$$

It thus follows that the ex-ante risk premium decreases (increases) in the informativeness of the accounting report when I_{t-1} is more (less) than $\gamma \cdot (1 - w) \cdot Q_t$, and is independent of the accounting information when $I_{t-1} = \gamma \cdot (1 - w) \cdot Q_t$.

□

Proof of Proposition 3:

We recall from the proof of Proposition 2 that the risk premium decreases (increases) in the precision of accounting information if $\gamma \cdot Q_t - Q_{t+1}$ is negative (positive), where

$$Q_{t-1} \equiv \sum_{\tau=0}^{\infty} (\gamma \cdot w)^{\tau} . I_{t+\tau-1}.$$

Since the firm grows at a constant rate of μ from date $t - 1$ through date T and reaches the steady state size of $I_{t-1} \cdot (1 + \mu)^{T-t+1}$ at date T, it follows that

$$Q_{t-1} = I_{t-1} \cdot \left[\frac{1 - [\gamma \cdot w \cdot (1 + \mu)]^{T-t+1}}{1 - \gamma \cdot w \cdot (1 + \mu)} + \frac{[\gamma \cdot w \cdot (1 + \mu)]^{T-t+1}}{1 - \gamma \cdot w} \right],$$

and

$$Q_t = I_t \cdot \left[\frac{1 - [\gamma \cdot w \cdot (1 + \mu)]^{T-t}}{1 - \gamma \cdot w \cdot (1 + \mu)} + \frac{[\gamma \cdot w \cdot (1 + \mu)]^{T-t}}{1 - \gamma \cdot w} \right].$$

For brevity, let us define

$$q \equiv \gamma \cdot (1 + \mu).$$

Using the above expressions for Q_{t-1} and Q_t, it can be verified that:

$$\gamma \cdot Q_t - Q_{t-1} = \frac{\Gamma(q)}{(1 - w \cdot q) \cdot (1 - w \cdot \gamma)}, \tag{22}$$

where

$$\Gamma(q) \equiv (1 - w \cdot \gamma) \cdot (q - 1) - (q \cdot w)^{T-t+1} \cdot (1 - w) \cdot (q - \gamma). \tag{23}$$

We note that $\Gamma(q) < 0$ for all $q \leq 1$. This implies that $\gamma \cdot Q_t - Q_{t-1}$ is negative for all $q \leq 1$ (i.e., all $\mu \leq r$). It thus follows that the risk premium decreases in the precision of accounting information for all all $\mu \leq r$.

We now investigate the sign of $\gamma \cdot Q_t - Q_{t-1}$ for the values of greater than 1. Using the definition in (23), it can be verified that (i) the function $\Gamma(\cdot)$ is strictly concave, (ii) $\Gamma(1) < 0$, and (iii) $\Gamma(w^{-1}) = 0$. Since $w^{-1} > 1$, these facts imply that the function $\Gamma(q)$ initially increases, takes its maximum value at some unique $\hat{q} > 1$ (with $\Gamma(\hat{q}) \geq 0$), and then decreases.

We need to consider two possibilities for the maximizer of $\Gamma(q)$: (i) $\hat{q} < w^{-1}$, and (ii) $\hat{q} \geq w^{-1}$. In case (i), the function $\Gamma(q)$ achieves its maximum at some point below w^{-1}. As a consequence, there exists a $q^* \in (1, \hat{q})$ such that $\Gamma(q^*) = \Gamma(w^{-1}) = 0$ and:

i $\Gamma(q) < 0$ for all $q \in (1, q^*)$,

ii. $\Gamma(q) > 0$ for all $q \in (q^*, w^{-1})$.

iii. $\Gamma(q) < 0$ for all $q > w^{-1}$.

Since $(1 - w \cdot \gamma) > 0$, we note from equation (22) that

$$sgn[\gamma \cdot Q_{t-1} - Q_t] = sgn[\Gamma(q) \cdot (w^{-1} - q)]. \tag{24}$$

It thus follows that there exists a $q^* < w^{-1}$ such that $\gamma \cdot Q_{t-1} - Q_t$ is negative for all $q < q^*$, and positive for all $q > q^*$. From the definition of q, we note that $q = 1$ corresponds to $\mu = r$. Define:

$$\mu^* \equiv (1 + r) \cdot q^* - 1.$$

Therefore the risk premium decreases (increases) in the precision of accounting information if the firm's growth rate is less (more) than μ^*, where $\mu^* > r$.

Consider now case (ii) above; that is, $\hat{q} \geq w^{-1}$. In this case, there exists a $q^* > w^{-1}$ such that $\Gamma(q)$ is negative for $q \in [1, w^{-1}]$, positive for $q \in (w^{-1}, q^*)$, and again negative for $q > q^*$. Therefore, it again follows from (24) that there exists a unique $\mu^* > r$ such that $\gamma \cdot Q_{t-1} - Q_t$ is negative for $\mu < \mu^*$, and positive for $\mu > \mu^*$.

To derive the upper bound on μ^* given in the statement of Proposition 3, we substitute

$Q_t = I_t + \gamma \cdot w \cdot Q_{t+1}$ and $I_t = (1+\mu) \cdot I_{t-1}$ in equation (21) to obtain

$$\gamma \cdot Q_t - Q_{t-1} = I_{t-1} \cdot [\gamma \cdot (1-w) \cdot (1+\mu) - 1] + \gamma^2 \cdot w \cdot (1-w) \cdot Q_{t+1}.$$

Since the second term on the right-hand side of the above equation is always positive, a sufficient condition for $\gamma \cdot Q_t - Q_{t-1}$ to be positive is that

$$\gamma \cdot (1-w) \cdot (1+\mu) - 1 \geq 0,$$

which is equivalent to

$$\mu \geq \frac{r+w}{1-w}.$$

Therefore the risk premium increases in the precision of accounting information for all $\mu \geq \frac{r+w}{1-w}$. This proves that the threshold growth rate μ^* must be such that $\mu^* \in \left(r, \frac{r+w}{1-w}\right)$.

$\square$

Proof of Lemma 2:

Similarly to the first step of the proof of Lemma 1, one can verify that the market clearing price of the firm's stock must satisfy

$$P_{t-1} = \gamma \cdot (E_{t-1}[Y_t] - \rho \cdot Var_{t-1}[Y_t]), \tag{25}$$

where $Y_t \equiv X_t - I_t + P_t$.

Observe that for $\tau \geq 2$, $IC_{t+\tau}$ and $AC_{t+\tau}$ are measurable at date t. Consider the following price process:

$$\begin{aligned} P_t \;=\; & \gamma E_t[X_{t+1}] - \gamma I_{t+1} - \gamma\rho Var_t[X_{t+1}] - \gamma^3 \rho Var_t[E_{t+1}[X_{t+2}]] \\ & -\gamma^3\rho^3 Var_t[Var_{t+1}[X_{t+2}]] + 2\gamma^3\rho^2 Cov_t[E_{t+1}[X_{t+2}], Var_{t+1}[X_{t+2}]] \\ & + \sum_{\tau=2}^{\infty} \gamma^\tau \cdot (E[X_{t+\tau}] - I_{t+\tau} - IC_{t+\tau} - AC_{t+\tau}). \end{aligned} \tag{26}$$

Note that in the expression above, only two terms, $\gamma E_t[X_{t+1}]$ and $\gamma\rho Var_t[X_{t+1}]$, depend on S_t. All other terms are independent of S_t since $X_{t+\tau}$ for $\tau \geq 2$ is independent of all random variables realized up to date t. Note further that P_t in equation (26) is independent of X_t. Therefore, if prices are given by (26), we have:

$$
\begin{aligned}
Var_{t-1}[Y_t] &= Var_{t-1}[X_t] + Var_{t-1}[P_t] \\
&= Var_{t-1}[X_t] + \gamma^2 \cdot Var_{t-1}[E_t[X_{t+1}]] \\
&\quad + \rho^2 \cdot \gamma^2 Var_{t-1}[Var_t[X_{t+1}]] - 2 \cdot \rho \cdot \gamma^2 \cdot Cov_{t-1}[E_t[X_{t+1}], Var_t[X_{t+1}]]
\end{aligned} \tag{27}
$$

It follows from equation (26) that

$$
E_{t-1}[P_t] = \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot (E[X_{t+\tau}] - I_{t+\tau} - IC_{t+\tau} - AC_{t+\tau}).
$$

Let us now apply the equation above and equation (27) to expand the right-hand side of equation (25):

$$
\begin{aligned}
\gamma \cdot (E_{t-1}[Y_t] - \rho \cdot Var_{t-1}[Y_t]) &= \gamma E_{t-1}[X_t] - \gamma I_t + \gamma \cdot \sum_{\tau=1}^{\infty} \gamma^{\tau} \cdot (E[X_{t+\tau}] - I_{t+\tau} - IC_{t+\tau} - AC_{t+\tau}) \\
&\quad - \gamma\rho Var_{t-1}[X_t] - \gamma^3 \rho Var_{t-1}[E_t[X_{t+1}]] \\
&\quad - \rho^3 \cdot \gamma^3 Var_{t-1}[Var_t[X_{t+1}]] + 2\rho^2\gamma^3 Cov_{t-1}[E_t[X_{t+1}], Var_t[X_{t+1}]] \\
&= P_{t-1},
\end{aligned}
$$

where the last equality follows from (26). Therefore, we have verified that the market-clearing condition (25) holds at all dates if prices are given by (26).

The ex-ante risk premium in period $t+1$ is then given by:

$$
\begin{aligned}
RP_{t+1} &= E_{t-1}[Y_{t+1} - (1+r) P_t] = E_{t-1}[\rho Var_t[Y_{t+1}]] \\
= \rho &\; E_{t-1}[Var_t[X_{t+1}]] + \rho\gamma^2 \cdot Var_t[E_{t+1}[X_{t+2}]] \\
&\quad + \rho^3 \cdot \gamma^2 Var_t[Var_{t+1}[X_{t+2}]] - 2 \cdot \rho^2 \cdot \gamma^2 \cdot Cov_t[E_{t+1}[X_{t+2}], Var_{t+1}[X_{t+2}]] \\
&= IC_{t+1} + AC_{t+1}.
\end{aligned}
$$

□

Proof of Proposition 4:

Let us employ the following notation:

$$
\begin{aligned}
E\left[X_{t+2}^{+}\right] &\equiv E[X_{t+2} | s_{t+1} = \lambda], \\
E\left[X_{t+2}^{-}\right] &\equiv E[X_{t+2} | s_{t+1} < \lambda],
\end{aligned}
$$

$$Var\left[X_{t+2}^{+}\right] \equiv Var\left[X_{t+2}|s_{t+1}=\lambda\right].$$

We first prove part (ii) to show that AC_{t+1} is always non-positive. Observe that $Var_{t+1}\left[X_{t+2}\right]$ is equal to zero with probability $F(\lambda)$ (when $x_{t+2}<\lambda$) and to $Var\left[X_{t+2}^{+}\right]$ with probability $1-F(\lambda)$. Therefore,

$$\rho Var_t\left[Var_{t+1}\left[X_{t+2}\right]\right]=\rho F(\lambda)\left(1-F(\lambda)\right)\left(Var\left[X_{t+2}^{+}\right]\right)^2. \tag{28}$$

Note further that

$$\begin{aligned} Cov_t\left[E_{t+1}\left[X_{t+2}\right],Var_{t+1}\left[X_{t+2}\right]\right] &= E_t\left[E_{t+1}\left[X_{t+2}\right]Var_{t+1}\left[X_{t+2}\right]\right]-E_t\left[X_{t+2}\right]E_t\left[Var_{t+1}\left[X_{t+2}\right]\right] \\ &= \left(1-F(\lambda)\right)Var\left[X_{t+2}^{+}\right]E\left[X_{t+2}^{+}\right]-\left(1-F(\lambda)\right)Var\left[X_{t+2}^{+}\right]E_t\left[X_{t+2}\right] \\ &= \left(1-F(\lambda)\right)Var\left[X_{t+2}^{+}\right]\left(E\left[X_{t+2}^{+}\right]-E_t\left[X_{t+2}\right]\right) \\ &= \left(1-F(\lambda)\right)F(\lambda)Var\left[X_{t+2}^{+}\right]\left(E\left[X_{t+2}^{+}\right]-E_t\left[X_{t+2}^{-}\right]\right). \end{aligned} \tag{29}$$

Equations (28) and (29) imply that

$$AC_{t+1}=-2\rho^2\gamma^2(1-F(\lambda))F(\lambda)Var\left[X_{t+2}^{+}\right]\left(E\left[X_{t+2}^{+}\right]-E_t\left[X_{t+2}^{-}\right]-\frac{\rho}{2}Var\left[X_{t+2}^{+}\right]\right). \tag{30}$$

It follows that $AC_{t+1}\leq 0$, if

$$E\left[X_{t+2}^{+}\right]-\frac{\rho}{2}Var\left[X_{t+2}^{+}\right]\geq E_t\left[X_{t+2}^{-}\right],$$

which holds because of the first-order stochastic dominance assumption on preferences. This proves claim (ii) of Proposition 4.

We next show that IC_{t+1} increases (decreases) in the degree of accounting conservatism if $\mu_t<r$ ($\mu_t>r$). Note that

$$IC_{t+1}=\rho\cdot I_{t-1}\cdot E_{t-1}\left[Var_t\left[x_{t+1}\right]\right]+\gamma^2\cdot\rho\cdot I_t\cdot Var_t\left[E_{t+1}\left[x_{t+2}\right]\right].$$

Since x_{t+1} and x_{t+2} are identically distributed, the law of total variance implies:

$$E_{t-1}\left[Var_t\left[x_{t+1}\right]\right]+Var_t\left[E_{t+1}\left[x_{t+2}\right]\right]=\sigma^2.$$

Our result will then follow from the same arguments as in the proof of Proposition 1 if we show that

$$Var_t\left[E_{t+1}\left[x_{t+2}\right]\right]$$

increases in λ.

Consider some $\lambda^{(1)} > \lambda^{(2)}$, and let $s_{t+1}^{(1)}$ and $s_{t+1}^{(2)}$ be the accounting reports corresponding to the policies given by $\lambda^{(1)}$ and $\lambda^{(2)}$, respectively. Specifically, $s_{t+1}^{(i)} = \min\left\{x_{t+2}, \lambda^{(i)}\right\}$. We can construct the following random variable:

$$\Delta = E\left[x_{t+2}|s_{t+1}^{(1)}\right] - E\left[x_{t+2}|s_{t+1}^{(2)}\right].$$

Let us verify that

$$E\left[\Delta|E\left[x_{t+2}|s_{t+1}^{(2)}\right]\right] = 0 \tag{31}$$

for all values of $E\left[x_{t+2}|s_{t+1}^{(2)}\right]$. If $E\left[x_{t+2}|s_{t+1}^{(2)}\right] < \lambda^{(2)}$, then $x_{t+2} < \lambda^{(2)} < \lambda^{(1)}$, and $\Delta = x_{t+2} - x_{t+2} = 0$. The event that $\left\{E\left[x_{t+2}|s_{t+1}^{(2)}\right] = E\left[x_{t+2}|s_{t+1}^{(2)} = \lambda^{(2)}\right]\right\}$ is the same as $\left\{x_{t+2} \geq \lambda^{(2)}\right\}$, and

$$\begin{aligned}
E\left[\Delta|E\left[x_{t+2}|s_{t+1}^{(2)}\right] = E\left[x_{t+2}|s_{t+1}^{(2)} = \lambda^{(2)}\right]\right] &= E\left[\Delta|x_{t+2} \geq \lambda^{(2)}\right] \\
&= E\left[x_{t+2}|x_{t+2} \geq \lambda^{(2)}\right] - E\left[x_{t+2}|x_{t+2} \geq \lambda^{(2)}\right] \\
&= 0.
\end{aligned}$$

Since

$$E\left[x_{t+2}|s_{t+1}^{(1)}\right] = E\left[x_{t+2}|s_{t+1}^{(2)}\right] + \Delta,$$

condition (31) implies that $E\left[x_{t+2}|s_{t+1}^{(1)}\right]$ is a mean-preserving spread of $E\left[x_{t+2}|s_{t+1}^{(2)}\right]$. Therefore,

$$Var_t\left[E\left[x_{t+2}|s_{t+1}^{(1)}\right]\right] \geq Var_t\left[E\left[x_{t+2}|s_{t+1}^{(2)}\right]\right],$$

and we have shown that $Var_t\left[E_{t+1}\left[x_{t+2}\right]\right]$ increases in λ. This concludes the proof of part (i) of Proposition 4.

We now turn to the proof of part (iii). Recall that

$$AC_{t+1} = -2\rho^2\gamma^2(1-F(\lambda))F(\lambda)\,Var\left[X_{t+2}^{+}\right]\left(E\left[X_{t+2}^{+}\right] - E_t\left[X_{t+2}^{-}\right] - \frac{\rho}{2}Var\left[X_{t+2}^{+}\right]\right)$$

$$= -2\rho^2\gamma^2(1-F(\lambda))Var\left[X_{t+2}^{+}\right]\left(E\left[X_{t+2}^{+}\right]-E_t\left[X_{t+2}\right]-\frac{\rho}{2}F(\lambda)\,Var\left[X_{t+2}^{+}\right]\right).$$

We can also rewrite IC_{t+1} as:

$$\begin{aligned} IC_{t+1} &= \rho\cdot I_{t-1}\cdot E_{t-1}\left[Var_t\left[x_{t+1}\right]\right]+\gamma^2\cdot\rho\cdot I_t\cdot Var_t\left[E_{t+1}\left[x_{t+2}\right]\right] \\ &= \rho\left(\gamma^2 Var\left[X_{t+2}\right]+\left(\frac{1}{(1+\mu_t)^2}-\gamma^2\right)E_t\left[Var_{t+1}\left[X_{t+2}\right]\right]\right) \\ &= C_1+\rho C_2(r,\mu)\cdot(1-F(\lambda))Var\left[x^{+}\right], \end{aligned}$$

where $C_1 \equiv \rho\gamma^2 I_t^2 Var\left[x_{t+2}\right] > 0$, $C_2 \equiv I_t^2\left(\frac{1}{(1+\mu_t)^2}-\gamma^2\right)$, and $Var(x^{+}) \equiv Var(x_{t+2}|s_{t+1} = \lambda)$. We note that C_1 is positive and does not depend on λ, while C_2 has the same sign as $r-\mu$ and is independent of λ.

Recall that the degree of conservatism is inversely related to λ. To verify that for sufficiently small values of ρ, the overall risk premium increases in conservatism for $\mu_t < r$ and decreases in conservatism for $\mu_t > r$, it suffices to check that if ρ is small, then the absolute value of the derivative of IC_{t+1} with respect to λ exceeds that of the derivative of AC_{t+1}.

It can be verified that

$$\frac{\partial IC_{t+1}}{\partial\lambda} = -\rho C_2(r,\mu)\,f(\lambda)\left(E\left[x^{+}\right]-\lambda\right)^2$$

and

$$\begin{aligned} \frac{\partial AC_{t+1}}{\partial\lambda} = \rho^2 C_3 f(\lambda)\cdot \quad & \Big\{\left(E\left(x^{+}\right)-\lambda\right)^2\left(E\left(x^{+}\right)-E(x)-\rho F(\lambda)\,Var\left(x^{+}\right)\right) \\ & -Var\left(x^{+}\right)\left(E\left(x^{+}\right)-\lambda-\frac{\rho}{2}Var\left(x^{+}\right)\right)\Big\}, \end{aligned}$$

where $C_3 = 2\gamma^2 I_t^2$ and $E(x^{+}) \equiv E(x_{t+2}|s_{t+1} = \lambda)$.

Since $\lambda \le 1$, there exist two constants C_4 and C_5 such that

$$\left(E\left[x^{+}\right]-\lambda\right)^2 \ge C_4$$

and

$$\Big|\left(E\left(x^{+}\right)-\lambda\right)^2\left(E\left(x^{+}\right)-E(x)-\rho F(\lambda)\,Var\left(x^{+}\right)\right)$$

$$-Var\left(x^{+}\right)\left(E\left(x^{+}\right)-\lambda-\frac{\rho}{2}Var\left(x^{+}\right)\right)\Big| \quad \leq C_5$$

for all λ. Then, there exists a ρ_0 such that

$$\rho|C_2(r,\mu)|f(\lambda)C_4 \geq \rho^2 C_3 f(\lambda) C_5$$

for any value of $\rho \leq \rho_0$. It follows that for $\rho \leq \rho_0$,

$$\left|\frac{\partial IC_{t+1}}{\partial\lambda}\right| \geq \left|\frac{\partial AC_{t+1}}{\partial\lambda}\right|$$

for all $\lambda \leq 1$. Therefore, the derivative of the overall risk premium with respect to λ will have the same sign as the derivative of IC_{t+1}. This concludes the proof of Proposition 4.

For future reference, we note that it follows from our discussion above that if $\rho \leq \rho_0$,

$$\begin{aligned}\left|\frac{\partial RP_{t+1}}{\partial\lambda}\right| &\leq 2\rho C_2(r,\mu) f(\lambda)\left(E\left[x^{+}\right]-\lambda\right)^2 \\ &\leq \rho C_6\end{aligned} \tag{32}$$

for some constant C_6 and all values of $\lambda \in [0,1]$.

□

Proof of Proposition 5:

We need to show that for sufficiently small values of ρ, the expected market-to-book ratio increases in the degree of accounting conservatism (decreases in λ). In this proof, we use the notation introduced in the proof of Proposition 4.

Let $P_t(s_t,\lambda)$ and $B_t(s_t,\lambda)$ denote, respectively, the price of the firm and its book value at date t, given the accounting signal realization s_t and capitalization factor λ. Recall that $s_t = \min\{x_{t+1},\lambda\}$. Therefore, the price function, $P_t(\cdot,\lambda)$, is discontinuous at λ. The expected market-to-book ratio can be written as:

$$E[PB_t] = \int_{\underline{x}}^{\lambda} \frac{P_t(s,\lambda)}{B_t(s,\lambda)} f(s)\,ds + (1-F(\lambda))\frac{P_t(\lambda,\lambda)}{B_t(\lambda,\lambda)}, \tag{33}$$

where $P_t(\lambda,\lambda)$ and $B_t(\lambda,\lambda)$ denote the price and book value at date t if no write-down is observed.

It can be verified that inequality (32) and the expression for price in (26) imply that there exist constants C_7 and ρ_1 such that for all $\rho < \rho_1$:

$$\frac{\partial P_t(s,\lambda)}{\partial \lambda} \leq \rho C_7$$

for all $s < \lambda$, and

$$\begin{aligned}
\frac{dP_t(\lambda,\lambda)}{d\lambda} &\leq \frac{\partial \gamma E[x^+]}{\partial \lambda} + \rho C_7 \\
&= \gamma \frac{f(\lambda)}{1-F(\lambda)} \left(E\left[x^+\right] - \lambda\right) + \rho C_7
\end{aligned}$$

for all λ.

Note further that for $s < \lambda$,

$$\frac{\partial B_t(s,\lambda)}{\partial \lambda} = I_t;$$

and

$$\frac{dB_t(\lambda,\lambda)}{d\lambda} = I_t + I_{t-1}.$$

We can now use equation (33) to differentiate the expected market-to-book ratio with respect to λ:

$$\begin{aligned}
\frac{\partial E[PB_t]}{\partial \lambda} &= \frac{\partial \int_{\underline{x}}^{\lambda} \frac{P_t(s,\lambda)}{B_t(s,\lambda)} f(s)\, ds}{\partial \lambda} + \frac{\partial \left\{(1-F(\lambda)) \frac{P_t(\lambda,\lambda)}{B_t(\lambda,\lambda)}\right\}}{\partial \lambda} \\
&\leq \int_{\underline{x}}^{\lambda} \frac{\rho C_7 B_t(s,\lambda) - I_t P_t(s,\lambda)}{B_t^2(s,\lambda)} f(s)\, ds + \frac{P_t(\lambda-,\lambda)}{B_t(\lambda,\lambda)} f(\lambda) - \frac{P_t(\lambda,\lambda)}{B_t(\lambda,\lambda)} f(\lambda) \\
&\quad + (1-F(\lambda)) \frac{\left(\gamma \frac{f(\lambda)}{1-F(\lambda)} (E[x^+] - \lambda) + \rho C_7\right) B_t(\lambda,\lambda) - (I_t + I_{t-1}) P_t(\lambda,\lambda)}{B_t^2(\lambda,\lambda)},
\end{aligned}$$

where $P_t(\lambda-,\lambda) = \lim_{s\to\lambda-} P_t(s,\lambda)$. For small values of ρ, $P_t(\lambda-,\lambda) - P_t(\lambda,\lambda)$ can be bounded as:

$$P_t(\lambda-,\lambda) - P_t(\lambda,\lambda) \leq \gamma\left(\lambda - E\left[x^+\right]\right) + \rho C_8.$$

Then, we have

$$\frac{\partial E\left[PB_t\right]}{\partial\lambda} \leq \int\limits_{\underline{x}}^{\lambda} \frac{\rho C_7 B_t\left(s,\lambda\right) - I_t P_t\left(s,\lambda\right)}{B_t^2\left(s,\lambda\right)} f\left(s\right) ds + \frac{\rho C_8}{B_t\left(\lambda,\lambda\right)} f\left(\lambda\right) + \left(1 - F\left(\lambda\right)\right) \frac{\rho C_7 B_t\left(\lambda,\lambda\right) - \left(I_t + I_{t-1}\right) P_t\left(\lambda,\lambda\right)}{B_t^2\left(\lambda,\lambda\right)}.$$

For sufficiently small values of ρ,[20]

$$\left(1 - F\left(\lambda\right)\right) \frac{\left(I_t + I_{t-1}\right) P_t\left(\lambda,\lambda\right)}{B_t^2\left(\lambda,\lambda\right)} + \int\limits_{\underline{x}}^{\lambda} \frac{I_t P_t\left(s,\lambda\right)}{B_t^2\left(s,\lambda\right)} f\left(s\right) ds$$

$$\geq \rho \int\limits_{\underline{x}}^{\lambda} \frac{C_7 B_t\left(s,\lambda\right)}{B_t^2\left(s,\lambda\right)} f\left(s\right) ds + \rho \frac{C_8}{B_t\left(\lambda,\lambda\right)} f\left(\lambda\right) + \rho\left(1 - F\left(\lambda\right)\right) \frac{C_7 B_t\left(\lambda,\lambda\right)}{B_t^2\left(\lambda,\lambda\right)} \tag{34}$$

for all λ, and, therefore,

$$\frac{\partial E\left[PB_t\right]}{\partial\lambda} \leq 0.$$

□

[20]Note that by choosing a sufficiently ρ, the first term in the LHS of (34) can be made to exceed the sum of the second and third terms of the RHS for all $\lambda \in [0, 1]$, whereas the second term in the LHS can be made to exceed the first term in the RHS for all $\lambda \in [0, 1]$.

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