Inflation, Risk, and Dividend Growth

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Abstract

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Keywords: Inflation; Risk; Dividend policy; CAPM
JEL classification: G12, G35

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Abstract

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1. Introduction

Corporate dividend policy represents one of the key unsolved puzzles in finance. In one of the earliest studies on the subject, Lintner (1956) observed that changes in dividends only partially reflect earnings variations. Lintner proposed that firms seem to increase dividend payments only after they are reasonably certain that they can maintain them over the long-run. Gordon (1959) argued that paying higher dividends increases company value because dividends are more certain than capital gains (this is what we call *the bird in hand theory*). Miller and Modigliani (1961) showed that in a perfect and efficient capital market, dividend policy is irrelevant to share value. Black (1976) claimed that paying dividends reduces firm value when the tax disadvantages of dividends are taken into account. Bhattacharya (1979) asserted that asymmetric information infers a signaling benefit from paying dividends. Jensen (1986) suggested that issuing dividends provides a mechanism for reducing agency costs by reducing the free cash flows available for unprofitable activities.

Following these classical papers, many other empirical and theoretical avenues have been take to clarify the question of dividends (see, for instance, the dividend literature review by Ed-Dafali et al., 2023). In one of the most promising avenues, Cao et al. (2022, p. 3) noted the negative relationship between risks and dividend payouts, initially proposed by Bajaj and Vijh (1990), Michaely et al. (1995), Jagannathan et al. (2000), Grullon et al. (2002), Carter and Schmidt (2008), Hussainey et al. (2011), Bergeron (2013a), Varela (2015), Chen et al. (2017), and Seifert and Gonenc (2018).[1] In accordance, Bergeron et al. (2019b) have asserted that firms operating in a high-risk context will, as a matter of

[1] See also Beaver et al. (1970), Pettit (1977), Eades (1982), and Baskin (1989).

prudence, be reluctant to pay generous current dividends (D_0), and will prefer to redistribute earnings later, with higher future dividends (D_1). As a result, in this context, firms will display low current dividends, and high expected dividend growth (D_1/D_0). Indeed, several empirical studies have confirmed the positive relationship between risk and dividend growth.[2] Moreover, as suggested by Grullon et al. (2002) and Brav et al. (2005), this relationship is consistent with the commonly-held notion that large, established firms, which tend to be low risk and exhibit high payout ratios, offer low expected dividend growth. This point of view is also held by, Al-Najjar and Hussainey (2009), Almeida et al. (2015), Athari (2021), and Ali and Hegazy (2022).

Recently, Basse and Reddemann (2011), Basse et al. (2014), and Base (2019) have also shown that inflation influences dividend growth rates in the United States and Europe, as firms seem to adjust their dividend policies to the expected price increases (see, in addition, Lotto, 2020, and Ed-Dafali et al., 2023, p. 14). However, none of these works include the negative relationship between risks and dividend payouts in their studies. This observation also applies to the corresponding positive link between risk and dividend growth.

In this paper, we examine the theoretical relationship between inflation, risk, and dividend growth. Our primary motivation is to characterize, from a theoretical point of view, the relationship between a firm's dividend growth rate and its risk, under the condition of inflation. Our model development is based on the standard definition of the expected real dividend growth rate. Its framework can incorporate one factor or several, and likewise, one or several time periods.

For one factor and one time period, the model development can be summarized as follows. First, we postulate that the representative agent calculates, for each firm, the mathematical expectation of the real dividend growth rate. Second, we assume that the real dividend growth rate of a firm is equal to the corresponding average rate in the economy, plus a disturbance term. Third, we suppose the existence of a particular company whose dividends have zero correlation with inflation. Using basic algebraic manipulations and the normality assumption, we obtain our first and main result.

Our first result indicates that the expected dividend growth of a firm is positively and linearly related to its inflation-dividend beta (obtained from the covariance between the inflation rate and the company's dividend growth rate). It shows that the expected dividend growth rate of the firm is equal to the corresponding expected rate of a company whose dividends have zero correlation with inflation, plus an adjusted quantity directly proportional the inflation-dividend beta of the firm. This result can be viewed as an inflation-dividend version of the classical capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965), the *zero-beta* model of Black (1972), or the Inflation-CAPM of

[2] See also Beaver et al. (1970) and Beaver and Manegold (1975).

Chen and Boness (1975). If a firm has an inflation-dividend beta near zero, then its expected dividend growth rate will be close to that of the uncorrelated company. If a firm has an inflation-dividend beta superior (inferior) to the corresponding average beta on the market, then its expected dividend growth rate will be superior (inferior) to the expected global market growth rate. Briefly, this first result suggests that inflation affects dividends in the form of a linear relationship between growth and betas, in a period-by-period context.

Moreover, if we accept the reasonable assumption that dividend growth rates are higher for high-risk firms, then our first result also suggests that the inflation-dividend beta represents a valid measure of risk (under the condition of inflation, in which the inflation rate is viewed as a stochastic or random variable). Therefore, in the present context, the expected dividend growth of a firm appears to be positively and linearly related to its risk, measured by its inflation-dividend beta.

Our first result can easily be extended to a multifactor model, using the different factors that influence inflation.

In asset pricing, multifactor models are more general than the original CAPM. They indicate that the expected return of an asset is positively related to several risk measures. These multifactor models were introduced by Merton (1973) and Ross (1976). In Merton's intertemporal model, state variables serve as added factors. In the arbitrage pricing theory (APT) proposed by Ross, asset returns are generated by different economic factors, and the expected asset return is a function of the asset's sensitivity to those factors. Following these fundamental theories, Fama and French (1993) proposed a three-factor model, based on the link between stock return, size, and book-to-market equity. The Fama-French model implies that the expected return of an asset is related to three factor sensitivities, calculated with market, size, and book-to-market factors. Many empirical works have further confirmed the importance of a multifactor approach, including Cochrane (1996), Lettau and Ludvigson (2001), Lawrence et al. (2007), Fama and French (2015, 2017), and Cox and Britten (2019), among others.

For many factors and one period, our model development can be summarized as follows. First, we assume that the inflation rate is generated by several economic factors. Second, we integrate our inflation generating process into our initial single factor prediction. Third, we use different covariance properties, apply basic algebraic manipulations, and write the corresponding multidimensional expression for the expected dividend growth rate.

Our second result indicates that the expected dividend growth rate of a firm is positively and linearly related to N sensitivity coefficients, given by the covariance between dividends and the economic factors that influence inflation. This result shows that the expected dividend growth rate of the firm could be described by a multilinear function such as, for example, the APT of Ross (1976). Again, if we accept the assumption of a positive relationship between dividend growth and risk, then our second result indicates that the different dividend sensitivity coefficients correspond to different risk measures. Therefore, in a multifactor context, the expected dividend growth of a firm appears to be positively and linearly related to N measures of risk, defined by the sensitivity of dividends to economic inflation factors.

Our second result can also be extended to several periods, adopting a long-run risk approach.

As mentioned by Bansal et al. (2016), among others, the long-run concept of risk initiated by Bansal and Yaron (2004) has attracted a great deal of attention in finance. Bansal and Yaron initially proposed that consumption and dividend growth rates include a small long-run component that could explain differences in asset expected returns. In accordance with this view, Bansal et al. (2005) showed that long-run covariance between dividends and aggregate consumption accounts for more than 60% of the cross-sectional differences in asset returns. Furthermore, Da (2009) observed similar results using the long-run covariance between earnings and aggregate consumption. Moreover, Bansal and Kiku (2011) revealed that the long-run relationship between dividends and consumption affects dividend growth rates and return dynamics. In addition, Bergeron (2013a) derived a theoretical stock valuation method that takes into account the long-run concept of risk. Likewise, in an empirical study, Bansal et al. (2016) established that long-run growth, volatility risk, and long-run risk are key elements influencing asset prices.

For many factors and many periods, our model development can be summarized, this time, as follows. First, we take our multifactor relationship and sum over many periods. Second, we divide by the number of periods to obtain an average relationship, over the long-run. Third, we isolate the long-run covariance between dividends and factors.

Our third result indicates that the expected dividend growth rate of a firm is positively and linearly related to N sensitivity coefficients, given by the long-run covariance between dividends and the economic factors that influence inflation. As before, if we accept the assumption of a positive relationship between dividend growth and risk, then our third result indicates that the different dividend sensitivity coefficients correspond to different risk measures, over the long-run. Thus, in the present context, the expected dividend growth of a firm now appears to be positively and linearly related to N measures of risk, defined by the dividend sensitivity to economic factors, over many periods. In this manner, our third result integrates the multidimensionality of uncertainty, as well as the long-run concept of risk.

Overall, our study follows different works related to dividend policy, inflation, and risks, expressed with multiple factors or many periods. Nevertheless, none of the above-mentioned works has developed a theoretical model of the relationship between dividend growth and risk, under the condition of inflation, with one or many factors, over the short and long-run. In this regard, the overall motivation of this study is to examine, from a theoretical point of view, the effect of inflation and risks on future dividends, using one and multiple factors, as well as one and multiple periods.

This point of view is consistent with the position of Bass et al. (2023) who noted that in spite of numerous research efforts (related to dividends) there still seems to be no clear picture (see also Mazouz et al., 2023). Moreover, as noted by Ali and Hegazy (2022) "Theoretically, the existing literature has little to say about the relation between dividend policy and risk."

The remainder of this paper is organized in five sections. Section 2 derives the expected dividend growth rate of a firm for one period and one factor. Section 3 expresses the expected dividend growth rate for one period and many factors. Section 4 expresses the expected dividend growth rate for many periods and many factors. Section 5 concludes. Technical demonstrations are reported in Appendices A, B, and C.

2. Dividend growth for one period and one factor

In this section, we derive the relationship between the dividend growth rate of a firm and its inflation-dividend covariance, for one period. Then, we offer some comments on the model.

The relationship between risk and dividend growth

Our model is based on the standard definition of the expected real dividend growth rate. More precisely, given the available information at time t $(t = 0, 1, 2, \dots, T)$, we postulate that the representative agent calculates, for each firm, the expected real dividend growth rate, as shown below:

$$1 + \mu_{it} = E_t\left[(1 + \tilde{g}_{i,t+1})/(1 + \tilde{\pi}_{t+1})\right], \tag{1}$$

where μ_{it} is the expected real dividend growth rate of firm i at time t $(i = 1, 2, \dots, N)$, $\tilde{g}_{i,t+1}$ is the (absolute) dividend growth rate of firm i between times t and $t+1$, and $\tilde{\pi}_{t+1}$ is the inflation rate between times t and $t+1$. [3] Here, $\tilde{g}_{i,t+1}$ is such that: $1 + \tilde{g}_{i,t+1} = \widetilde{D}_{i,t+1}/D_{it}$; where $\widetilde{D}_{i,t+1}$ represents the dividend of firm i at time $t+1$, and D_{it} represents the dividend of firm i at time t. As well, $\tilde{\pi}_{t+1}$ is such that: $1 + \tilde{\pi}_{t+1} = \widetilde{CPI}_{t+1}/CPI_t$; where $\widetilde{CPI}_{t+1}$ represents the *Consumer Price Index* at time $t+1$, and CPI_t represents the index at time t. To simplify the notation, we can also write:

[3] In this paper, the tilde (~) indicates a random variable, while the index t indicates that we consider the available information at time t. Additionally, operators E_t, V_t, and Cov_t refer respectively to mathematical expectations, variance and covariance.

$$1+\mu_{it}=1+E_t[\tilde{g}^r_{i,t+1}], \tag{2}$$

where $\tilde{g}^r_{i,t+1}$ is the real dividend growth rate of firm i between times t and $t+1$, such that: $1+\tilde{g}^r_{i,t+1}=(1+\tilde{g}_{i,t+1})/(1+\tilde{\pi}_{t+1})$. In addition, we assume that the real dividend growth rate of a firm is equal to the corresponding average rate in the economy, plus a disturbance term, that is:

$$\tilde{g}^r_{i,t+1}=\mu_t+\tilde{\varepsilon}_{i,t+1}, \tag{3}$$

$$0=E_t[\tilde{\varepsilon}_{i,t+1}],$$

where $\tilde{\varepsilon}_{i,t+1}$ is the standard random error term, and μ_t is the mathematical expectation of the average real dividend growth rate in the economy, at time t, defined in this manner: $\mu_t\equiv E_t\sum_{i=1}^{N}\tilde{g}^r_{i,t+1}/N$. Our *inflation-dividend process*, described by equation (3), simply suggests that, for different states of nature and probabilities, the real dividend growth rate of a stock will sometimes be superior and sometimes inferior to the corresponding average rate in the economy (viewed as a reference value or benchmark). For example, if the benchmark value for the real dividend growth rate in the economy is 2%, then, in accordance with our equation (3), the equivalent rate on any stock should fluctuate at around 2%. As we will show below, this point of view is fully consistent with a positive relationship between risk and dividend growth, described in nominal terms. Introducing equation (3) into equation (2), we have:

$$1+\mu_{it}=1+E_t[\mu_t+\tilde{\varepsilon}_{i,t+1}], \tag{4}$$

and integrating equation (4) into equation (1), we get:

$$1+\mu_t=E_t[(1+\tilde{g}_{i,t+1})/(1+\tilde{\pi}_{t+1})]. \tag{5}$$

To further simplify the notation, we can express:

$$1+\mu_t=E_t[\tilde{I}_{t+1}(1+\tilde{g}_{i,t+1})], \tag{6}$$

where $\tilde{I}_{t+1}\equiv 1/(1+\tilde{\pi}_{t+1})$ represents the (stochastic) *Inflation factor* at time $t+1$. In the same way, assuming the existence of a particular company whose dividends have zero correlation with inflation, we can express:

$$1+\mu_t=E_t[\tilde{I}_{t+1}(1+\tilde{g}_{z,t+1})], \tag{7}$$

where the letter *z* identifies the *zero covariance company*. Equation (6) minus (7) gives:

$$0 = E_t\left[\tilde{I}_{t+1}(\tilde{g}_{i,t+1} - \tilde{g}_{z,t+1})\right]. \tag{8}$$

Equation (8) is similar in form to the *fundamental equation of asset pricing*, using the *stochastic discount factor* and excess returns (see, for example, Campbell 2000, p. 1520). Taking the expectation on each side of equation (8) allows us to release the index t of the conditional operator, to show:

$$0 = E\left[\tilde{I}_{t+1}(\tilde{g}_{i,t+1} - \tilde{g}_{z,t+1})\right]. \tag{9}$$

From equation (9), and the covariance definition, we have:

$$0 = Cov[\tilde{I}_{t+1}, \tilde{g}_{i,t+1} - \tilde{g}_{z,t+1}] + E[\tilde{I}_{t+1}]E[\tilde{g}_{i,t+1} - \tilde{g}_{z,t+1}], \tag{10}$$

and from the basic property of the *zero covariance company*, we arrive at:

$$0 = Cov[\tilde{I}_{t+1}, \tilde{g}_{i,t+1}] + E[\tilde{I}_{t+1}]E[\tilde{g}_{i,t+1} - \tilde{g}_{z,t+1}]. \tag{11}$$

Isolating the expected dividend growth rate indicates:

$$E\left[\tilde{g}_{i,t+1}\right] = E[\tilde{g}_{z,t+1}] - (1/E[\tilde{I}_{t+1}])Cov[\tilde{I}_{t+1}, \tilde{g}_{i,t+1}]. \tag{12}$$

Equation (12) reveals that the expected dividend growth rate of a firm is directly proportional to its inflation-dividend covariance. To facilitate the estimation of this equation, we suppose that the dividend growth rate of the firm and the inflation rate are bivariate normally distributed. More precisely, based on Stein's lemma (see Huang and Litzenberger, 1988, p. 101) we know that if variables x and y are bivariate normally distributed, then $Cov[y, f(x)] = E[f'(x)]Cov[y, x]$. Thus, from the definition of $\tilde{I}_{t+1}$, and the normality assumption, equation (12) now becomes:

$$E\left[\tilde{g}_{i,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] - (1/E[\tilde{I}_{t+1}])(-1)E[(\tilde{I}_{t+1})^{-2}]Cov[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}], \tag{13}$$

or equivalently:

$$E\left[\tilde{g}_{i,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + Cov[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}]E[(\tilde{I}_{t+1})^{-2}]/E[\tilde{I}_{t+1}]. \tag{14}$$

Equation (14) clearly shows that the relationship between $E\left[\tilde{g}_{i,t+1}\right]$ and $Cov[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}]$ is positive. Indeed, since $\tilde{\pi}_{t+1}$ is such that: $1 + \tilde{\pi}_{t+1} = \widetilde{CP}I_{t+1}/CPI_t$, where $\widetilde{CP}I_{t+1}$ and CPI_t are, by definition, positive, then it follows that the value $1 + \tilde{\pi}_{t+1}$ is also positive, as is the value of the *Inflation factor* $\tilde{I}_{t+1}$, previously defined as follows: $\tilde{I}_{t+1} \equiv 1/(1 +$

$\tilde{\pi}_{t+1}$). As a result, $E[\tilde{I}_{t+1}]$ and $E[(\tilde{I}_{t+1})^{-2}]$ are superior to zero, and equation (14) describes a positive relationship. For the market portfolio, noted by the index *m*, we also have:

$$E\left[\tilde{g}_{m,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + Cov[\tilde{\pi}_{t+1}, \tilde{g}_{m,t+1}]E[(\tilde{I}_{t+1})^{-2}]/E[\tilde{I}_{t+1}], \qquad (15)$$

and integrating equation (15) into equation (14), we can write:

$$E\left[\tilde{g}_{i,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)\frac{Cov[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}]}{Cov[\tilde{\pi}_{t+1}, \tilde{g}_{m,t+1}]}. \qquad (16)$$

Multiplying by $V[\tilde{\pi}_{t+1}]$ on each side of equation (16), we finally obtain (see Appendix A):

$$E\left[\tilde{g}_{i,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)\frac{\beta_{it}}{\beta_{mt}}, \qquad (17)$$

$$\beta_{it} \equiv Cov\left[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}\right]/V[\tilde{\pi}_{t+1}],$$

$$\beta_{mt} \equiv Cov\left[\tilde{\pi}_{t+1}, \tilde{g}_{m,t+1}\right]/V[\tilde{\pi}_{t+1}].$$

We call the resulting coefficient β_{it}, in equation (17), the *inflation-dividend beta* of firm i, at time t. It is equal to the covariance between the inflation rate and the dividend growth rate of the firm, divided by the inflation rate variance. This measures how sensitive the firm's dividends are to inflation. In the same manner, β_{mt} is the *inflation-dividend beta* of the market portfolio, at time t. This measures the sensitivity of the aggregate market dividend to inflation fluctuations.

Equation (17) represents our first (and main) result. This equation indicates that the expected dividend growth rate of a firm is positively and linearly related to its *inflation-dividend beta*. It demonstrates that the expected dividend growth rate of the firm equals the dividend growth rate of the *zero covariance company*, plus an adjusted quantity directly proportional the inflation-dividend beta of the firm. The form of equation (17) is close to the main prediction of the standard CAPM, or its *zero-beta* variant (see also the Consumption-CAPM as presented in Huang and Litzenberger, 1988, p. 208). If firm i has a β_{it} equal to zero, then its expected dividend growth rate corresponds to the intercept, given by the corresponding rate for the *zero-covariance company*. If β_{it} is superior to zero, then its expected rate is superior to the intercept, and the function is linear, as is the case with the CAPM (and its most important extensions).

In that sense, our first result, expressed by equation (17), demonstrates that inflation influences dividends, from a theoretical point of view, in a period-by-period context. Moreover, as previously noted, if we accept the reasonable assumption that dividend growth rates are higher for high-risk firms, then equation (17) clearly reveals that the dividend-inflation covariance represents a measure of risk. This is how we can establish that the expected dividend growth of a firm is positively and linearly related to its risk, measured by its inflation-dividend covariance (or beta).

Comments on the dividend-beta relationship

In this subsection, we offer several comments on the relationship between the dividend growth rate of a firm and its inflation-dividend beta, over one period of time. Our first comment is related to the normality assumption. Our second comment concerns the *zero-covariance company*. Our third comment describes two possible applications of our inflation model.

The normality assumption

Like asset returns, dividend growth rates cannot be normally distributed because the largest possible negative rate is minus 100%. Indeed, the normality assumption for dividend growth rates implies that there is a finite possibility that dividend rates will be less than minus 100%. Fortunately, from a practical point of view, the probability of observing dividend growth rates as low as minus 100% may be so small that the normality assumption adopted here seems acceptable. Moreover, we know that use of a normal distribution for similar cases is very common in finance (see, for example, Campbell 2018, Chapter 2, p. 25). Nonetheless, in Appendix B we show that the normality assumption assumed in this section 2 can be relaxed, using directly the (stochastic) *Inflation factor* ($\tilde{I}_{t+1}$).

The meaning of risk

We have already mentioned that the tilde (~) indicates a random variable, which also indicates that the inflation rate ($\tilde{\pi}_{t+1}$) can take different values in the future. In this context of uncertainty, our developments reveal that the appropriate risk measure is the inflation-dividend beta. We reached this outcome by (1) demonstrating that *betas* and *dividend growth* are positively and linearly related, and (2) assuming the existence of a positive relationship between *risk* and *dividend growth*.

To better define the meaning of our risk measure, we further assume that a firm's dividend growth rate ($\tilde{g}_{i,t+1}$) is generated by the inflation rate, as shown below:

$$\tilde{g}_{i,t+1} = \alpha_{it} + \beta_{it}\tilde{\pi}_{t+1} + \tilde{\epsilon}_{i,t+1},$$

with $0 = E_t\left[\tilde{\epsilon}_{i,t+1}\right] = Cov_t\left[\tilde{\epsilon}_{i,t+1}, \bullet\right]$, where α_{it} is the intercept associated with firm i at time t, and β_{it} is the dividend sensitivity to the inflation factor, for firm i at time t. Accepting this additional assumption, it is easy to prove that the variance of the variable $\tilde{g}_{i,t+1}$ is given by:

$$V_t[\tilde{g}_{i,t+1}] = \beta_{it}^2 V_t[\tilde{\pi}_{t+1}] + V_t[\tilde{\epsilon}_{i,t+1}].$$

This implies that a firm's total dividend risk, expressed with its total variance, can be partitioned into two parts. That is to say:

Total risk = systematic risk + unsystematic risk.

Here, the systematic risk is a measure of how a firm's future dividend growth rate covaries with the inflation rate, while the unsystematic risk represents the part of the risk that is independent of this macroeconomic variable. Put differently, the variance, $V_t[\tilde{g}_{i,t+1}]$, is the total dividend risk that can be apportioned to systematic risk, $\beta_{it}^2 V_t[\tilde{\pi}_{t+1}]$, and unsystematic risk $V_t[\tilde{\epsilon}_{i,t+1}]$. In our model, this mean that the unsystematic risk (or specific risk) does not affect the firm's expected dividend growth rate, because it does not appear in the main prediction, formulated by equation (17). The systematic risk, however, clearly appears in equation (17) via the dividend sensitivity to the inflation factor or, in our formulation, the inflation-dividend beta, represented by β_{it}. Besides, like the familiar consumption-beta (see Huang and Litzenberger, 1988, p. 208) the level of a single beta is unknown, a priori, but we can easily see that the ratio β_{it}/β_{mt}, used in equation (17), should result in an average of *one* ($1 = \beta_{mt}/\beta_{mt}$).

The zero-covariance company

The upshot of the *zero-beta* model of Black (1972) is that the major results of the classical CAPM of Sharpe (1964) and Lintner (1965) do not require the existence of a purely risk-free asset. *Standard beta* (with returns) is still the appropriate measure of systematic risk for an asset, and the linearity of the model is still obtained. More precisely, the *zero-beta* model reveals that the required rate of return of an asset is equal to the expected rate of return of the efficient portfolio that has zero covariance with the market portfolio, plus a risk premium directly proportional to its standard beta. However, the theoretical uncorrelated portfolio has no practical equivalency in real markets, contrary to the riskless asset that could be reasonably estimated by a short-term Treasury bill (for example). Likewise, our *zero-covariance company*, whose dividends have zero correlation with inflation, is unknown, a priori. Accordingly, our dividend process, formulated above, indicates that:

$$\tilde{g}_{z,t+1} = \alpha_{zt} + \tilde{\epsilon}_{z,t+1},$$

where the index *z* identifies the *zero-covariance company*. In the present case, our dividend process also indicates that:

$$E_t[\tilde{g}_{z,t+1}] = \alpha_{zt}.$$

In light of this, we can imagine that the *zero-covariance company* is a particular firm in which the expected dividend growth rate is only defined by the historical average inflation rate. It could be, for example, a large established company with low risk, that systematically offers (year after year) a dividend growth rate around 3 % ($\alpha_{zt} = 3$ %), regardless of the inflation fluctuations (or predictions).

Nevertheless, for practical applications, to avoid a direct estimation of $E\left[\tilde{g}_{z,t+1}\right]$, we can refer to equation (15) and use the following result, obtained from the market portfolio:

$$E\left[\tilde{g}_{z,t+1}\right] = E\left[\tilde{g}_{m,t+1}\right] - Cov[\tilde{\pi}_{t+1}, \tilde{g}_{m,t+1}]E[(\tilde{I}_{t+1})^{-2}]/E[\tilde{I}_{t+1}].$$

This will allow us to estimate our first and main result, expressed by equation (17), without any direct determination of the theoretical dividend growth rate of the *zero-covariance company*.

Practical applications

As mentioned by Elton et al. (2014, Chapter 18), the pursuit of a valid method for valuation of common stocks has consumed a great deal of effort over many years. Among the most influential models, the classic *dividend growth model* stipulates that the intrinsic value of a stock is determined by its dividend growth rate and required return. To help estimate the required return, an investor can count on innumerable works about the relationship between risk and returns.[4] However, there are practically no works on dividend growth rate estimation that can be used for valuation of stocks and firm equities. The *dividend growth model* establishes that the current value of a stock, V_0, is equivalent to (see, for example, Peleg 2014, Chapter 6):

$$V_0 = D_1/(r - g),$$

where D_1 is the next dividend, r is the required return, and g is the constant dividend growth rate. The primary practical application that we propose for our model concerns the determination of g. We propose to apply our first result to stock valuation, by incorporating into the formulation above our main prediction to determine the constant growth rate. In this manner, the evaluation of the intrinsic value of a stock will both integrate dividend growth and dividend sensitivity to inflation. Moreover, in accordance with the *dividend growth model*, the *cost of equity* for a particular firm, ρ, is equal to:

$$\rho = g + D_1/P_0,$$

[4] For a discussion on the theoretical or empirical relationship between risk and returns, see, for example, Campbell (2000), Cochrane (2011) or Campbell (2018).

where P_0 represents the firm's stock market price. We now propose to apply our first result to the *cost of equity*, by incorporating into the latter formulation our main prediction to determine the constant dividend growth rate. Adopting this procedure, a manager can estimate the firm's *weighted average cost of capital*, which, again, will integrate both dividend growth and dividend sensitivity to inflation.

3. Dividend growth for one period and many factors

In this section, we extend our unidimensional model to a multidimensional model. First, we present our inflation multifactor process. Then, we derive the corresponding multidimensional expression for the expected dividend growth. Our goal is similar to any multifactor model that, given a particular multifactor process, derives the appropriate relation with risk.[5]

The inflation multifactor process

The central assumption of our extended model is that the inflation rate is generated by several economic factors. More precisely, given the available information at time t, we assume that the inflation rate is a linear function of K factors, as shown below:

$$\tilde{\pi}_{t+1} = b_{0t} + b_{1t}\tilde{F}_{1,t+1} + b_{2t}\tilde{F}_{2,t+1} + \cdots + b_{Kt}\tilde{F}_{K,t+1} + \tilde{\epsilon}_{t+1}, \tag{18a}$$

with:

$$0 = E_t[\tilde{\epsilon}_{t+1}] = \ Cov_t[\tilde{\epsilon}_{t+1},\ \bullet],$$

where, for $k = 1, 2, 3, \ldots, K$, $\tilde{F}_{k,t+1}$ is the factor k that influences the inflation rate at time $t+1$, b_{0t} is the intercept associated with the inflation multifactor model at time t, b_{kt} is the sensitivity of the inflation rate to the factor k at time t, and $\tilde{\epsilon}_{t+1}$ is the usual random term at time $t+1$.[6] To simplify the notation, we can also rewrite the multifactor process using this compact form:

$$\tilde{\pi}_{t+1} = b_{0t} + \boldsymbol{b}_t'\tilde{\boldsymbol{F}}_{t+1} + \tilde{\epsilon}_{t+1}, \tag{18b}$$

where $\tilde{\boldsymbol{F}}_{t+1}$ is a *column vector* containing the element $\tilde{F}_{1,t+1}, \tilde{F}_{2,t+1}, \ldots, \tilde{F}_{K,t+1}$, while $\boldsymbol{b}_t'$ is a *row vector* containing the elements $b_{1t}, b_{2t}, \ldots, b_{Kt}$. Like the multifactor process adopted in Campbell (2000, p. 1525) to estimate of the standard *stochastic discount factor*, the inflation process expressed by equation (18) represents only an approximation of reality

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[5] See, for example, the intertemporal-CAPM of Merton (1973) or the classical APT of Ross (1976). See also, Campbell (2000, p. 1525), or Bergeron (2013b).

[6] In equation (18a), the expected random term is zero, as the covariance between this random term and any undefined variable (expressed by the *point*).

and the factors that we should integrate into the model (such as production costs or economic growth) are not determined (a priori). Moreover, considering the dynamic nature of markets, this dividend process can change rapidly. Besides, any of these (significant) factors can be expressed in such a way that its effect on inflation is positive, that is: $b_{kt} > 0$, for $k = 1, 2, 3, \dots, K$.

The multidimensional relationship with risk

From equation (14), we can write:

$$E\left[\tilde{g}_{i,t+1}\right] = \lambda_{0t} + \lambda_t Cov\left[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}\right]/V[\tilde{\pi}_{t+1}], \tag{19}$$

with $\lambda_{0t} \equiv E\left[\tilde{g}_{z,t+1}\right]$, and $\lambda_t \equiv V[\tilde{\pi}_{t+1}]E[(\tilde{I}_{t+1})^{-2}]/E[\tilde{I}_{t+1}]$. Now, integrating equation (18b) into equation (19) shows:

$$E\left[\tilde{g}_{i,t+1}\right] = \lambda_{0t} + \lambda_t Cov\left[b_0 + \boldsymbol{b}_t'\widetilde{\boldsymbol{F}}_{t+1} + \tilde{\epsilon}_{t+1}, \tilde{g}_{i,t+1}\right]/V[\tilde{\pi}_{t+1}]. \tag{20}$$

From the covariance properties, it is easy to demonstrate, using simple manipulations, that:

$$E\left[\tilde{g}_{i,t+1}\right] = \lambda_{0t} + \lambda_t Cov\left[\boldsymbol{b}_t'\widetilde{\boldsymbol{F}}_{t+1}, \tilde{g}_{i,t+1}\right]/V[\tilde{\pi}_{t+1}], \tag{21}$$

or, equivalently:

$$E\left[\tilde{g}_{i,t+1}\right] = \lambda_{0t} + \lambda_t Cov\left[b_{1t}\tilde{F}_{1,t+1} + \cdots + b_{Kt}\tilde{F}_{K,t+1}, \tilde{g}_{i,t+1}\right]/V[\tilde{\pi}_{t+1}]. \tag{22}$$

Rearranging, we can write:

$$E\left[\tilde{g}_{i,t+1}\right] = \lambda_{0t} + \frac{b_{1t}\lambda_t}{V[\tilde{\pi}_{t+1}]} Cov\left[\tilde{F}_{1,t+1}, \tilde{g}_{i,t+1}\right] + \cdots + \frac{b_{Kt}\lambda_t}{V[\tilde{\pi}_{t+1}]} Cov\left[\tilde{F}_{K,t+1}, \tilde{g}_{i,t+1}\right], \tag{23}$$

and multiplying by $V\left[\tilde{F}_{k,t+1}\right]$ on each side of equation (23), for all $k = 1, 2, 3, \dots, K$, we finally obtain this multilinear function:[7]

$$E\left[\tilde{g}_{i,t+1}\right] = \lambda_{0t} + \lambda_{1t}\beta_{1it} + \lambda_{2t}\beta_{2it} + \cdots + \lambda_{Kt}\beta_{Kit}, \tag{24}$$

$$\lambda_{kt} \equiv b_{kt}\lambda_t V\left[\tilde{F}_{k,t+1}\right]/V[\tilde{\pi}_{t+1}],$$

$$\beta_{kit} \equiv Cov\left[\tilde{F}_{k,t+1}, \tilde{g}_{i,t+1}\right]/V\left[\tilde{F}_{k,t+1}\right].$$

[7] In Appendix C, we derive a similar result to equation (24) using the dividend multifactor process proposed in Bergeron (2013b, p. 185).

Here, the resulting coefficient β_{kit}, in equation (24), represents the dividend sensitivity to factor k, for firm i, at time t. It is equal to the covariance between a specific factor and the dividend growth rate of the firm, divided by the factor's variance. To put it differently, it measures how sensitive the firm's dividends are to a given factor that influences inflation, and thereby influences dividends. Moreover, as before, it is apparent in equation (24), that λ_{kt} is positive ($\lambda_{kt} > 0$). Indeed, since b_{kt} and λ_t are superior to zero, by definition or construction, then parameter λ_{kt} will be positive (for $k = 1, 2, 3, \ldots, K$).

Equation (24) represents our second result. This equation now indicates that the expected dividend growth rate of a firm is positively and linearly related to K sensitivity coefficients (or betas), given by the covariance between dividends and inflation factors. From a theoretical point of view, this result suggests, this time, that economic factors influence dividends, via inflation, in a period-by-period context.

If the number of factors equals one ($K = 1$), then the inflation linear generating process, formulated by equation (18a) or (18b), assumes that:

$$\tilde{\pi}_{t+1} = b_{0t} + b_{1t}\tilde{F}_{1,t+1} + \tilde{\epsilon}_{t+1}, \tag{25}$$

where $\tilde{F}_{1,t+1}$ is the only factor. Thus, integrating equation (25) into equation (24), we have:

$$E\left[\tilde{g}_{i,t+1}\right] = \lambda_{0t} + \lambda_{1t}\beta_{1it}, \tag{26}$$

$$\lambda_{1t} = b_{1t}\lambda_t V\left[\tilde{F}_{1,t+1}\right]/V[\tilde{\pi}_{t+1}],$$

$$\beta_{1it} = Cov\left[\tilde{F}_{1,t+1}, \tilde{g}_{i,t+1}\right]/V\left[\tilde{F}_{1,t+1}\right].$$

In addition, if we determine that $\tilde{\pi}_{t+1}$ is perfectly correlated with $\tilde{F}_{1,t+1}$, and such that $\tilde{\epsilon}_{t+1}$ is equal to zero, then we have:

$$\lambda_{1t} = b_{1t}\lambda_t b_{1t}^{-2} V[\tilde{\pi}_{t+1}]/V[\tilde{\pi}_{t+1}] = b_{1t}^{-1}\lambda_t,$$

$$\beta_{1it} = b_{1t}^{-1} Cov\left[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}\right]/V[\tilde{\pi}_{t+1}]b_{1t}^{-2} = b_{1t} Cov\left[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}\right]/V[\tilde{\pi}_{t+1}],$$

which indicates that equation (26) is now equivalent to our first result, initially proposed in equation (17), knowing that: $\lambda_t = \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)/\beta_{mt}$.

In short, the latter relationship reveals that our first (and main) result represents a particular case of our second result, expressed by equation (24). In that sense, we can argue that our initial unidimensional model can be viewed as a special case of our multidimensional model, just as the CAPM can be viewed as a special case of the APT or the Intertemporal-CAPM.

4. Dividend growth for many periods and many factors

In this section, we extend our multifactor model from one time period to many time periods. First, we use our second prediction and sum over all periods. Then, we divide by the number of periods to obtain an average relationship. Our mathematical manipulations follow Bergeron (2013b). Thereafter, we offer additional comments on this extension.

The model multiperiodic extension

This model extension is based on the fundamental nature of dividends, which represent a flow of payments, over many periods. It is also based on the recent success of the long-run approach in which risk is measured with dividends over more than one period of time. More precisely, since dividends are paid over several periods, we can take equation (24), sum from time zero to time $T-1$, and write the following expression:

$$\sum_{t=0}^{T-1} E\left[\tilde{g}_{i,t+1}\right] = \sum_{t=0}^{T-1} (\lambda_{0t} + \lambda_{1t}\beta_{1it} + \lambda_{2t}\beta_{2it} + \cdots + \lambda_{Kt}\beta_{Kit}). \tag{27}$$

Using the basic properties of the summation operator, we have:

$$\sum_{t=0}^{T-1} E\left[\tilde{g}_{i,t+1}\right] = \sum_{t=0}^{T-1} \lambda_{0t} + \sum_{t=0}^{T-1} \lambda_{1t}\beta_{1it} + \sum_{t=0}^{T-1} \lambda_{2t}\beta_{2it} + \cdots + \sum_{t=0}^{T-1} \lambda_{Kt}\beta_{Kit}. \tag{28}$$

Multiplying by $\sum_{t=0}^{T-1} \lambda_{1t}$, $\sum_{t=0}^{T-1} \lambda_{2t}$, …, and $\sum_{t=0}^{T-1} \lambda_{Kt}$ on each side of equation (28) gives:

$$\sum_{t=0}^{T-1} E\left[\tilde{g}_{i,t+1}\right] = \sum_{t=0}^{T-1} \lambda_{0t} + \sum_{t=0}^{T-1} \lambda_{1t} \sum_{t=0}^{T-1} w_{1t}\beta_{1it} + \cdots + \sum_{t=0}^{T-1} \lambda_{Kt} \sum_{t=0}^{T-1} w_{Kt}\beta_{Kit}, \tag{29}$$

where $w_{kt} \equiv \lambda_{kt} / \sum_{t=0}^{T-1} \lambda_{kt}$, with $\sum_{t=0}^{T-1} w_{kt} = 1$, for every $k = 1, 2, 3, \dots, K$. Dividing by T on each side of equation (29) shows that:

$$\left(\frac{1}{T}\right) \sum_{t=0}^{T-1} E\left[\tilde{g}_{i,t+1}\right] =$$

$$\left(\frac{1}{T}\right) \sum_{t=0}^{T-1} \lambda_{0t} + \left(\frac{1}{T}\right) \sum_{t=0}^{T-1} \lambda_{1t} \sum_{t=0}^{T-1} w_{1t}\beta_{1it} + \cdots + \left(\frac{1}{T}\right) \sum_{t=0}^{T-1} \lambda_{Kt} \sum_{t=0}^{T-1} w_{Kt}\beta_{Kit}. \tag{30}$$

Consequently, adopting a compact notation, we finally obtain this formulation:

$$\bar{g}_i = \bar{\lambda}_0 + \bar{\lambda}_1\bar{\beta}_{1i} + \bar{\lambda}_2\bar{\beta}_{2i} + \cdots + \bar{\lambda}_K\bar{\beta}_{Ki}, \tag{31}$$

$$\bar{g}_i \equiv \textstyle\sum_{t=0}^{T-1} E\left[\tilde{g}_{i,t+1}\right]/T,\ \ \bar{\lambda}_0 \equiv \sum_{t=0}^{T-1} \lambda_{0t}/T,$$
$$\bar{\lambda}_k \equiv \textstyle\sum_{t=0}^{T-1} \lambda_{kt}/T,\ \ \bar{\beta}_{ki} \equiv \sum_{t=0}^{T-1} w_{kt}\beta_{kit},$$

for all $k = 1, 2, \dots, K$. In equation (31), estimators $\bar{g}_i$, $\bar{\lambda}_0$, and $\bar{\lambda}_k$ correspond, respectively, to the arithmetic averages of time values $E\left[\tilde{g}_{i,t+1}\right]$, λ_{0t}, and λ_{kt}, while coefficient $\bar{\beta}_{ki}$ can be viewed as the weighted average sensitive coefficient of time values β_{kit}. In particular, we define the estimator $\bar{g}_i$ as the long-run dividend growth rate of firm i, and $\bar{\beta}_{ki}$ as the long-run dividend sensitivity coefficient to factor k, of firm i. In addition, since λ_{kt} are superior to zero, for all periods, the corresponding value $\bar{\lambda}_k$ will be positive.

Equation (31) represents our third result. Here, this equation indicates that the dividend growth rate of a firm is positively and linearly related to K sensitivity coefficients, given by the covariance between dividends and economic factors, over the long-run. From a theoretical point of view, in this case, the result suggests that economic factors influence dividends over the long-run, via inflation. If we sum over one period (only), then T equals 1, and we have the following values:

$$\bar{g}_i = \textstyle\sum_{t=0}^{1-1} E\left[\tilde{g}_{i,t+1}\right]/1,\ \ \bar{\lambda}_0 = \sum_{t=0}^{1-1} \lambda_{0t}/1,$$
$$\bar{\lambda}_k = \textstyle\sum_{t=0}^{1-1} \lambda_{kt}/1,\ \ \bar{\beta}_{ki} = \sum_{t=0}^{1-1} w_{kt}\beta_{kit},$$

or if we prefer,

$$\bar{g}_i = E\left[\tilde{g}_{i,t+1}\right],\ \ \bar{\lambda}_0 = \lambda_{0t},\ \ \bar{\lambda}_k = \lambda_{kt}, \text{ and }\ \bar{\beta}_{ki} = \beta_{kit},$$

which reveals that our second result, expressed by equation (24), for one period and many factors, represents a special case of our third result, expressed by equation (31), for many periods and many factors.

Comments on the multifactor framework over many periods

In this subsection, we offer three specific comments on the multifactor framework over many periods. These comments concern (1) the complexity of the framework, (2) the risk-return relationship and our model contribution, and (3) the stability of factor sensitivities.

The complexity of the framework

Initially, the classical CAPM of Sharpe (1964) and Lintner (1965) used a very simple static framework based on two periods only, and other restrictive assumptions. Thereafter, many sophisticated extended models have been developed to better capture the real complexity of financial markets. For example, Black (1972) relaxed the free-risk assumption, using a theoretical zero-beta portfolio. Merton (1973) presented a sophisticated framework in which trading takes place continuously over time. Chen and Boss (1975) incorporated inflation. Ross (1976) proposed a multifactor approach. Breeden (1979) adopted an intertemporal framework with aggregate consumption. Hansen and Richard (1987) demonstrated the importance of a conditional procedure. Epstein and Zin (1989) innovated by integrating recursive utility functions. Fama and French (1993) elaborated a multifactor model with three specific factors. Bansal and Yaron (2004) revealed the importance of a long-run approach. Bergeron (2013b), and Bergeron et al. (2019b) integrated a long-run approach, as well as a multifactor procedure. In adopting different sophisticated developments in the present manuscript, we simply follow the above-mentioned studies to better integrate the complexity of financial decisions (with many factors and many periods).

The risk-return relationship and our model contribution

As we previously mentioned, a large number of influential models have been proposed for asset pricing. These models descript the risk-return relationship using different contexts (with one or many factors over one or many periods).[8] As we also mentioned, many studies indicate a positive relationship between risk and dividend growth (see, in particular, Grullon et al., 2002; Brav et al.,2005; Al-Najjar and Hussainey, 2009; Bergeron, 2013a, 2013b; Almeida et al., 2015; Athari, 2021; and Ali and Hegazy, 2022). Nevertheless, none of these dividend studies is based on the main predictions of the major asset pricing models (such as the CAPM and the APT). In applying to dividends the same type of solid frameworks developed in asset pricing, we are contributing to the dividend literature by offering novel sophisticated approaches to, again, better integrate the complexity of financial decisions.

The stability of factor sensitivities

Some can maintain that the stability of the factor coefficients may not always hold in practice. Fortunately, however, the main predictions of our model allow us to integrate the variability of the coefficients. Indeed, if we isolate the different beta coefficients presented in equations (17) and (24), we can then observe that all of these values integrate an index of time (t), which means that these values can fluctuate over time. In addition, if we observe the different manipulations used in this section 4, we can see that all of the different time-

[8] Among the most influential models, we have the CAPM of Sharpe (1964) and Lintner (1965), the zero-beta CAPM of Black (1972), the multifactor-intertemporal CAPM of Merton (1973), the arbitrage pricing theory (APT) of Ross (1976), the consumption CAPM of Breeden (1979), the conditional CAPM of Hansen and Richard (1987), the recursive preference model of Epstein and Zin (1989), the three-factor model of Fama and French (1993), the long-run approach of Bansal and Yaron (2004), the two-beta model of Campbell and Vuolteenaho (2004), and the three-beta model of Campbell et al. (2018).

betas (associated to a particular factor) are reduced to only one average beta, reflected the long-run sensitivity. As a result, the long-run procedure adopted here can be viewed as a possible way to reduce the negative effect of instability. In practice, we can use the following procedure (for example). First, calculate each beta. Second, estimate the cross-sectional parameters (λs) given by equation (24), for each period. Third, determine the average value for each lambda (λs). In so doing, we can solve (or reduce) the problem of the instability of our different lambdas and betas.

5. Conclusion

In this paper, we examined the theoretical relationship between inflation, risk, and dividend growth. Our primary goal was to characterize the link between the expected dividend growth rate of a firm and its risk, under the condition of inflation. Our model development was based on the standard definition of the expected real dividend growth rate, and its framework used one or many factors, as well as one or several time periods. Firstly, we showed that the expected dividend growth rate of a firm is positively and linearly related to its *inflation-dividend beta*, interpreted as a risk measure. Then, we assumed that the inflation rate is a function of many factors, and extended our unidimensional model to a multidimensional model with several sensitivity betas. Thereafter, we adopted a long-run approach, and proposed that our last extension can also be prolonged over many periods, with different long-run betas.

As such, the main contributions of this paper can be summarized as follows. First, this paper suggests that inflation affects dividends, from a theoretical point of viewed. Second, it demonstrates that risk, estimated with dividends, inflation and economic factors, influences dividend growth rates, over the short and long-run. Third, it characterizes the theoretical relationship between the expected dividend growth rate of a firm and its risk, under the condition of inflation. Fourth, in practice, it offers a simple additional tool to determine the price of a stock or the corresponding equity value, and to estimate the cost of equity for a firm.

Overall, our findings support the view that inflation should be considered when estimating risk, dividend growth and firm values, in a context of one or many factors, as well as one or several time periods.

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Appendix A (main result)

Appendix A demonstrates the link between equations (16) and (17), derived in section 2. Indeed, multiplying by $V_t[\tilde{\pi}_{t+1}]$ on each side of equation (16) gives:

$$V[\tilde{\pi}_{t+1}]E\left[\tilde{g}_{m,t+1}\right] = V[\tilde{\pi}_{t+1}]E\left[\tilde{g}_{z,t+1}\right] + \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)\frac{Cov[\tilde{\pi}_{t+1},\tilde{g}_{i,t+1}]}{Cov[\tilde{\pi}_{t+1},\tilde{g}_{m,t+1}]}V[\tilde{\pi}_{t+1}]. \quad \text{(A1)}$$

This allows us to write:

$$E\left[\tilde{g}_{m,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)\frac{Cov[\tilde{\pi}_{t+1},\tilde{g}_{i,t+1}]}{Cov[\tilde{\pi}_{t+1},\tilde{g}_{m,t+1}]}\frac{V[\tilde{\pi}_{t+1}]}{V_t[\tilde{\pi}_{t+1}]}. \quad \text{(A2)}$$

Rearranging, we have:

$$E\left[\tilde{g}_{m,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)\frac{Cov[\tilde{\pi}_{t+1},\tilde{g}_{i,t+1}]}{V_t[\tilde{\pi}_{t+1}]}\frac{V[\tilde{\pi}_{t+1}]}{Cov[\tilde{\pi}_{t+1},\tilde{g}_{m,t+1}]}. \quad \text{(A3)}$$

Finally, we obtain our main result, initially presented by equation (17). That is:

$$E\left[\tilde{g}_{m,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)\beta_{it}\beta_{mt}^{-1}, \quad \text{(A4)}$$

with $\beta_{it} \equiv Cov\left[\tilde{\pi}_{t+1},\tilde{g}_{i,t+1}\right]/V[\tilde{\pi}_{t+1}]$,

and $\beta_{mt} \equiv Cov\left[\tilde{\pi}_{t+1},\tilde{g}_{m,t+1}\right]/V[\tilde{\pi}_{t+1}]$.

Appendix B (without normality)

Appendix B shows that the normality assumption, adopted in section 2, can be relaxed, using directly the (stochastic) *Inflation factor* ($\tilde{I}_{t+1}$). Indeed, from equation (12), and the definition of variable $\tilde{I}_{t+1}$ ($\tilde{I}_{t+1} \equiv (1+\tilde{\pi}_{t+1})^{-1}$), we can write:

$$E\left[\tilde{g}_{i,t+1}\right] = E[\tilde{g}_{z,t+1}] - (1/E[\tilde{I}_{t+1}])Cov[(1+\tilde{\pi}_{t+1})^{-1}, \tilde{g}_{i,t+1}]. \quad \text{(B1)}$$

Again, equation (B1) reveals that the expected dividend growth rate of a firm is directly proportional to its inflation-dividend covariance. Also, for the market portfolio, noted by the index *m*, we have:

$$E\left[\tilde{g}_{m,t+1}\right] = E[\tilde{g}_{z,t+1}] - (1/E[\tilde{I}_{t+1}])Cov[(1+\tilde{\pi}_{t+1})^{-1}, \tilde{g}_{m,t+1}], \quad \text{(B2)}$$

and integrating equation (B2) into equation (B1), we get:

$$E\left[\tilde{g}_{i,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)\frac{Cov[\tilde{I}_{t+1}, \tilde{g}_{i,t+1}]}{Cov[\tilde{I}_{t+1}, \tilde{g}_{m,t+1}]}. \quad \text{(B3)}$$

Multiplying by $V[\tilde{I}_{t+1}]$ on each side of equation (B3), we now obtain:

$$E\left[\tilde{g}_{i,t+1}\right] = E\left[\tilde{g}_{z,t+1}\right] + \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right)\frac{\mathrm{B}_{it}}{\mathrm{B}_{mt}}, \quad \text{(B4)}$$

$$\mathrm{B}_{it} \equiv Cov\left[\tilde{I}_{t+1}, \tilde{g}_{i,t+1}\right]/V[\tilde{I}_{t+1}],$$

$$\mathrm{B}_{mt} \equiv Cov\left[\tilde{I}_{t+1}, \tilde{g}_{m,t+1}\right]/V[\tilde{I}_{t+1}].$$

Here, the resulting coefficient B_{it}, expressed in capital letters, still represents how sensitive the firm's dividends are to inflation, and equation (B4) can be interpretated as the same manner as equation (17), previously derived in section 2.

Appendix C (dividend process)

Appendix C derives an analogous result to equation (24), adopting the dividend multifactor process proposed in Bergeron (2013b, p. 185). More precisely, given the available information at time t, we now assume that firm dividend growth rates are generated by K economic factors, as shown below:

$$\tilde{g}_{i,t+1} = a_{it} + b_{1it}\tilde{X}_{1,t+1} + b_{2it}\tilde{X}_{2,t+1} + \cdots + b_{Kit}\tilde{X}_{K,t+1} + \tilde{\epsilon}_{i,t+1}, \quad \text{(C1)}$$

with $0 = E_t[\tilde{\epsilon}_{i,t+1}] = Cov_t[\tilde{\epsilon}_{i,t+1}, \bullet]$, where, for $k = 1, 2, 3, \dots, K$, $\tilde{X}_{k,t+1}$ is the factor k at time $t+1$, a_{it} is the intercept associated with firm i at time t, and b_{kit} is the dividend sensitivity to factor k, for firm i at time t. Again, to simplify the notation, we can use matrix algebra to rewrite the multifactor process in this compact form:

$$\tilde{g}_{i,t+1} = a_{it} + \boldsymbol{b}'_{it}\widetilde{\boldsymbol{X}}_{t+1} + \tilde{\epsilon}_{i,t+1}, \tag{C2}$$

where, $\widetilde{\boldsymbol{X}}_{t+1}$ is a *column vector* containing the element $\tilde{X}_{1,t+1}, \tilde{X}_{2,t+1}, \dots, \tilde{X}_{K,t+1}$, while $\boldsymbol{b}'_{it}$ is a *row vector* containing the elements $b_{1it}, b_{2it}, \dots, b_{Kit}$. Here, the rate of inflation, market dividend growth, industrial production, and aggregate consumption growth, could be considered as potential factors that influence firm dividend growth rates. If the number of factors equals one ($K = 1$), and if this factor represents the inflation rate, then equation (C1) or (C2) shows:

$$\tilde{g}_{i,t+1} = a_{it} + b_{\pi it}\tilde{\pi}_{t+1} + \tilde{\epsilon}_{t+1},$$

where $b_{\pi it}$ represents the dividend sensitivity to the inflation rate for firm i at time t, and where it is easy to prove that: $b_{\pi it} = Cov[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}]/V[\tilde{\pi}_{t+1}]$. Integrating equation (C2) in (19) shows:

$$E[\tilde{g}_{i,t+1}] = \lambda_{0t} + \lambda_t Cov[\tilde{\pi}_{t+1}, a_{it} + \boldsymbol{b}'_{it}\widetilde{\boldsymbol{X}}_{t+1} + \tilde{\epsilon}_{t+1}]/V[\tilde{\pi}_{t+1}]. \tag{C3}$$

From the covariance properties, and the definition of $\tilde{\epsilon}_{i,t+1}$, we can write:

$$E[\tilde{g}_{i,t+1}] = \lambda_{0t} + \lambda_t Cov[\tilde{\pi}_{t+1}, \boldsymbol{b}'_{it}\widetilde{\boldsymbol{X}}_{t+1}]/V[\tilde{\pi}_{t+1}], \tag{C4}$$

or, equivalently:

$$E[\tilde{g}_{i,t+1}] = \lambda_{0t} + \lambda_t Cov[\tilde{\pi}_{t+1}, b_{1it}\tilde{X}_{1,t+1} + \cdots + b_{Kit}\tilde{X}_{K,t+1}]/V[\tilde{\pi}_{t+1}]. \tag{C5}$$

Rearranging, we can also write:

$$E[\tilde{g}_{i,t+1}] = \lambda_{0t} + \frac{Cov[\tilde{\pi}_{t+1}, \tilde{X}_{1,t+1}]\lambda_t}{V[\tilde{\pi}_{t+1}]} b_{1it} + \cdots + \frac{Cov[\tilde{\pi}_{t+1}, \tilde{X}_{K,t+1}]\lambda_t}{V[\tilde{\pi}_{t+1}]} b_{Kit}. \tag{C6}$$

Finally, we obtain the following multilinear function:

$$E[\tilde{g}_{i,t+1}] = \lambda_{0t} + \lambda^*_{1t}b_{1it} + \lambda^*_{2t}b_{2it} + \cdots + \lambda^*_{Kt}b_{Kit}, \tag{C7}$$

with $\lambda^*_{kt} \equiv Cov[\tilde{\pi}_{t+1}, \tilde{X}_{k,t+1}]\lambda_t/V[\tilde{\pi}_{t+1}]$, for $k = 1, 2, 3, \dots, K$., and this relationship is similar to the previous equation (24) derived with the inflation process, expressed by equation (18a) or (18b). Besides, if the inflation rate is the only factor that affects dividends, in the dividend process formulated by equation C1 or C2, then:

$$E\left[\tilde{g}_{i,t+1}\right] = \lambda_{0t} + \lambda_{1t}^{*} b_{1it}, \tag{C7}$$

$$\lambda_{1t}^{*} \equiv \frac{Cov\left[\tilde{\pi}_{t+1}, \tilde{X}_{1,t+1}\right]\lambda_t}{V\left[\tilde{\pi}_{t+1}\right]} = \frac{Cov\left[\tilde{\pi}_{t+1}, \tilde{\pi}_{t+1}\right]\lambda_t}{V\left[\tilde{\pi}_{t+1}\right]} = \lambda_t,$$
$$b_{1it} = b_{\pi it} = Cov\left[\tilde{\pi}_{t+1}, \tilde{g}_{i,t+1}\right] / V\left[\tilde{\pi}_{t+1}\right] \equiv \beta_{it},$$

and we obtain, again, our first and main result, initially proposed by equation (17), since parameter $\lambda_t = \left(E\left[\tilde{g}_{m,t+1}\right] - E\left[\tilde{g}_{z,t+1}\right]\right) / \beta_{mt}$.