

Price-Earnings Ratios: Growth and Discount Rates*

Andrew Ang[†]
Columbia University and NBER

Xiaoyan Zhang[‡]
Purdue University

This Version: 20 May 2011

*We thank Geert Bekaert, Sigbjørn Berg, and Tørres Trovik for helpful discussions. The on-line appendix contains further results and details of data and estimation, which is available at <http://www.columbia.edu/~aa610>

[†]Columbia Business School, 3022 Broadway 413 Uris, New York NY 10027, ph: (212) 854-9154; email: aa610@columbia.edu; WWW: <http://www.columbia.edu/~aa610>.

[‡]Krannert School of Management, Purdue University, West Lafayette, IN 47907. Ph: (765) 496-7674; email: zhang654@purdue.edu WWW: <http://web.ics.purdue.edu/~zhang654/>

Abstract

Movements in price-earnings ratios reflect variation in discount rates and changes in growth opportunities. We decompose market-level price-earnings ratios into a no-growth component, which depends only on future discount rates, and a growth component, the Present Value of Growth Opportunities (PVGO). We value both components allowing for time-varying risk-free rates, predictable cashflows, stochastic payout ratios, and changing discount rates. While implied discount rates exhibit significant time variation, growth opportunities account for approximately 95% of the variation and 80% of the level of price-earnings ratios.

1 Introduction

In a present value model, movements in price-earnings (PE) ratios must reflect variation in discount rates, which embed risk premiums, and growth opportunities, which involve the cash-flow and earnings generating capacity of firm investments.¹ We decompose PE ratios into a no-growth value, which is defined to be the perpetuity value of future earnings that are held constant with full payout of earnings, and the Present Value of Growth Opportunities (PVGO), which is the value of the stock in excess of the no-growth value, using a dynamic model which accounts for time-varying risk premiums and stochastic growth opportunities.

Importantly, we take into account a stochastic investment opportunity set with time-varying growth and discount rates. PE ratios can be high not only because growth opportunities are perceived to be favorable, they can also be high if expected returns are low. For example, during the late 1990s and early 2000s PE ratios were very high. This could be due to high prices incorporating large growth opportunities, but Jagannathan, McGrattan and Scherbina (2001) and Claus and Thomas (2001), among others, argue that during this time, discount rates were low. In contrast to our no-growth and PVGO decompositions in which both discount rates and growth rates are stochastic, in the standard “MBA” decompositions of no-growth and PVGO components discount rates and growth rates are constant. Other standard analysis in industry, such as the ratio of the PE to growth (often called the PEG ratio) implicitly assigns all variation in PE ratios to growth opportunities because it does not allow for time-varying discount rates.

We apply the model to the market-level PE ratio, as measured by the S&P500 index. We find that discount rates exhibit large variation: 27.5% of the variation in total returns is due to persistent, time-varying expected return components. However, while the variation of discount rates is large, most of the variation of PE ratios reflects growth components. No-growth components account for 20.7%, on average, of the level of the PE ratio and the remainder, 79.3%, is due to growth, or PVGO, components. Over 95% of the variation of PE ratios is due to time variation in growth opportunities.

2 Static Case

It is instructive to first consider the standard decomposition of a PE ratio into no-growth and growth components typically done in MBA-level finance classes. This exposition is adapted

¹ This decomposes the value of a firm into the value of assets in place plus real options, or growth opportunities. This decomposition was recognized as early as Miller and Modigliani (1961).

from Bodie, Kane and Marcus (2009, p597). Suppose that earnings grow at rate g , the discount rate is δ , and the payout ratio is denoted by po . The value of equity, P , is then given by

$$P = \frac{EA \cdot po}{\delta - g} = \frac{EA \cdot po}{\delta - g}, \quad (1)$$

where EA is expected earnings next year. The PE ratio, $PE = P/EA$, is then simply

$$PE = \frac{P}{EA} = \frac{po}{\delta - g}. \quad (2)$$

We decompose the market value, P , into a no-growth and growth component. The latter is called the present value of growth opportunities (PVGO). The no-growth value is defined as the present value of future earnings with no growth (so $g = 0$ and $po = 1$):

$$P^{ng} = \frac{EA}{\delta}. \quad (3)$$

The growth component is defined as the remainder:

$$PVGO = \frac{EA \cdot po}{\delta - g} - \frac{EA}{\delta} = \frac{EA \cdot (g - (1 - po)\delta)}{r(r - g)}, \quad (4)$$

and the two sum up to the total market value:

$$P = P^{ng} + PVGO.$$

While the decomposition of firm value into no-growth and PVGO components is important because, by definition, the no-growth component involves only discount rates, and the PVGO component involves both discount rate and cashflow growth effects. Understanding which component dominates gives insight into what drives PE ratios. However, the static case cannot be used to decompose PE ratios into no-growth and PVGO values over time because it assumes that earnings growth, g , discount rates, δ , and payout ratios, po , remain constant over time. Clearly, this is not true. Thus, to examine no-growth and PVGO values of PE ratios, we need to build a dynamic model.

3 The Dynamic Model

We make two changes to the static case to handle time-varying investment opportunities. First, we put “ t ” subscripts on the variables indicating that they change over time. Second, for analytical tractability we work in log returns, log growth rates, and log payout ratios. We define the discount rate, δ_t as

$$\delta_t = \ln E_t[(P_{t+1} + D_{t+1})/P_t], \quad (5)$$

where P_t is the equity price at time t and D_t is the dividend at time t . Earnings growth is defined as

$$g_t = \ln \left(\frac{EA_t}{EA_{t-1}} \right), \quad (6)$$

where EA_t is earnings at time t . Finally, the log payout ratio, po_t , is given by

$$po_t = \ln \left(\frac{D_t}{EA_t} \right). \quad (7)$$

In this notation, if $\delta_t = \bar{\delta}$, $g_t = \bar{g}$, and $po_t = \bar{po}$ were all constant, then the familiar PE ratio in equation (2) written in simple growth rates or returns would be given by

$$\frac{P}{EA} = \frac{\exp(\bar{po})}{\exp(\bar{\delta} - \bar{g}) - 1}.$$

3.1 Factors

We specify factors, X_t , which drive price-earnings ratios. The first three factors in X_t are the risk-free rate r_t^f , earnings growth g_t , and the payout ratio, po_t . We also include two other variables which predict returns: the growth rate of industrial production, ip_t , and term spreads, $term_t$. We select these variables after searching for variables which on their own forecast either total returns, or earnings growth, or both. We also include a latent factor, f_t , which captures variation in expected returns not accounted for by the observable factors. We specify the latent factor, f_t , to be orthogonal to the other factors. Thus, $X_t = (r_t^f \ g_t \ po_t \ ip_t \ term_t \ f_t)'$.

We assume that the state variables X_t follow a VAR(1):

$$X_{t+1} = \mu + \Phi X_t + \Sigma \varepsilon_{t+1}, \quad (8)$$

where $\varepsilon_t \sim \text{iid } N(0, I)$. The companion form, Φ , allows earnings growth and payout ratios to be predictable both by past earnings growth and payout ratios and other macro variables. The long-run risk model of Bansal and Yaron (2004) incorporates a highly persistent factor in the conditional mean of cashflows. Our model accomplishes the same effect by including persistent variables in X_t , especially the risk-free rate and payout ratio which are both highly autocorrelated.

To complete the model, we assume that discount rates, δ_t , are a linear function of state variables X_t :

$$\delta_t = \delta_0 + \delta_1' X_t. \quad (9)$$

The specification (9) nests the special cases of constant total expected returns by setting $\delta_1 = 0$ and the general case of time-varying discount rates when $\delta_1 \neq 0$. Since f_t is latent, we place a unit coefficient in δ_1 corresponding to f_t for identification.

3.2 The Dynamic Price-Earnings Ratio

Under assumptions (8) and (9), the dynamic PE ratio can be written as

$$PE_t = \sum_{i=1}^{\infty} \exp(a_i + b_i' X_t). \quad (10)$$

The coefficients a_i and b_i are given in the Appendix.²

Our model of the PE ratio belongs to an asset pricing literature that builds dynamic valuation models. The approaches of Campbell and Shiller (1988a) and Vuolteenaho (2002) to model price-dividend and PE ratios, respectively, require log-linearization assumptions. In contrast, our model produces analytically tractable solutions for PE ratios. Recently, Bekaert, Engstrom and Grenadier (2010) and van Binsbergen and Koijen (2010) examine dynamic price-dividend ratios in models with closed-form solutions, but not price-earnings ratios. Our model is more related to the analytical dynamic earnings models of Ang and Liu (2001) and Bakshi and Chen (2005), where cashflows are predictable and discount rates vary over time. However, Ang and Liu (2001) model price-to-book ratios instead of PE ratios and Bakshi and Chen's (2005) model of the PE ratio requires the payout ratio to be constant.

3.3 Growth and No-Growth Components

The no-growth PE ratio has the interpretation of a perpetuity, where at each time a unit cashflow is discounted by the cumulated market discount rates prevailing up until that time. In the full PE in equation (10), growth occurs by ploughing back earnings into the firm. In the no-growth PE, earnings are fully paid out and consequently the payout ratio does not directly influence the no-growth PE value. However, the payout ratio is not irrelevant in the no-growth PE because the payout ratio is a state variable and its dynamics are allowed to influence future earnings through Φ in the VAR.

The no-growth price earnings ratio, PE_t^{ng} , where earnings growth is everywhere zero and the payout ratio is equal to one, can be written as

$$PE_t^{ng} = \sum_{i=1}^{\infty} \exp(a_i^* + b_i^{*'} X_t), \quad (11)$$

where a_i^* and $b_i^{*'}$ are given in the Appendix.

We define the present value of growth opportunities (PVGO) as the difference between the PE ratio, which incorporates growth, and the no-growth PE:

$$PE_t = PE_t^{ng} + PVGO_t.$$

² A full derivation is available in the online Appendix.

4 Empirical Results

4.1 Data

We take data on dividend yields, PE ratios, price returns (capital gain only), and total returns (capital gain and dividends) on the S&P 500 index over 1953:Q1 to 2009:Q4. The Appendix describes the data in more detail.

The top panel of Figure 1 plots the log index of the S&P500 total return index. The decline during the mid-1970s recession, the strong bull market of the 1990s, the decline after the tech bubble in the early 2000s, and the drop due to the recent financial crisis over 2008-9 are clearly visible. The middle panel graphs the PE ratio. The PE ratio averages 18.5 over the sample. The PE ratio suddenly increases in 2008:Q4 to 60.7 and reaches a peak of 122 in 2009:Q2. At the end of the sample 2009:Q4, the PE comes down to 21.9. The large increase in PE ratios over 2008:Q4-2009:Q3 is due to large, negative reported earnings in 2008:Q4 during the financial crisis. This causes the moving four-quarter average of earnings to sharply decrease. While prices declined over the financial crisis, there was an even greater decrease in earnings reported during this time, causing the increase in PE ratios. The last panel of Figure 1 reports S&P500 dividend yields, which reach a low during the end of the bull market in 2000.

4.2 Estimation Results

Table 1 reports the parameter estimates of the model. The two most significant predictors of the discount rate are earnings growth, with a coefficient of 0.38, and industrial production with a coefficient of -1.28. The estimated VAR parameters show that all factors are highly persistent and this persistence dominates: no other factor Granger-causes risk-free rates, earnings growth, or payout ratios except the variables themselves.³

We plot the estimated discount rate in Figure 2. The full discount rate is plotted in the black solid line and we overlay the implied discount rate without the f_t factor in the red dashed line. The two discount rates have a 0.91 correlation. Thus, the observable factors capture most of the variation in expected returns. Without the latent factor, the observable factors $z_t = (r_t^f, g_t, po_t, ip_t, term_t)$ account for 18.0% of the variance of total returns and adding the latent factor brings the proportion up to 27.5%.

Figure 2 shows that discount rates declined noticeably over the 1990s from 14.5% in 1991:Q1 to -14.5% in 2002:Q1. The latter corresponded to then an all-time high of the PE in the sample

³ Estimation of the model is discussed in the online appendix.

of 46.5. The latent factor is very negative during this time – the model explains the high PE by estimating very low discount rates. Recently during the financial crisis, discount rates are again negative. For example, in 2008:Q4 the discount rate is -16.3%. This is the quarter with pronounced negative reported earnings and the PE starts to increase to 60.7 at this time due to the low earnings relative to market values. The model again explains the high PE with a low discount rate. The low discount rates at this time are caused by the large decrease in earnings growth. Note that returns over 2008-9 during the financial crisis were very low.

4.3 Drivers of the PE Ratio

In Table 2, we report variance decompositions of the PE ratio. We compute the variance of the PE implied by the model through the sample where the factor z is held constant at its unconditional mean, $\text{var}_z(PE)$. The variance decomposition due to factor z is given by $1 - \text{var}_z(PE)/\text{var}(PE)$, where $\text{var}(PE)$ is the variance of the PE ratio in data. These decompositions do not sum to one because the factors are correlated. Table 2 shows that the macro variables play a large role in explaining the dynamics of PE ratios. Risk-free rates, earnings growth, and payout ratios explain 18%, 38%, and 70%, respectively, of the variance of PE ratios. The variance attribution for industrial production is negative because turning off industrial production results in more volatile discount rates, and greater volatility of PE ratios. The latent factor, f , plays an important role in matching PE ratios with a variance attribution of 71%. This is consistent with Figure 2 where there are some occasionally pronounced differences between discount rates produced only with macro variables and discount rates estimated with the latent factor.

4.4 Growth and No-Growth Decompositions

Figure 3 plots the no-growth components in the dashed red line together with the PE in data shown in the blue solid line. Most of the variation of the PE ratio is due to growth components. The average no-growth PE defined in equation (11) is 3.8 compared to an average PE ratio in data of 18.5. Thus, no-growth components account for, on average, 20.7% of the PE ratio and most of the level of the total PE is due to the PVGO. The no-growth component is remarkably constant and has a volatility of 0.853 compared to a volatility of 12.7 for the PE ratio. Figure 3 clearly shows that the no-growth value is relatively constant. A variance decomposition of the PE ratio is:

$$\begin{array}{cccc}
\text{var}(PE_t) & = & \text{var}(PE_t^{ng}) & + & \text{var}(PVGO_t) & + & 2\text{cov}(PE_t^{ng}, PVGO_t) \\
100\% & & 0.5\% & & 94.8\% & & 4.7\%
\end{array}$$

Thus, 95% of price-earnings variation is explained by growth components or the PVGO term. The perpetuity value of no-growth is relatively constant because discount rates are highly mean-reverting: the year-on-year autocorrelation of discount rates over the sample is 0.34. Thus, the discounted earnings in the no-growth PE rapidly mean-revert to their long-term average.

In Table 3, we report various correlations of the no-growth and PVGO PEs. The no-growth and PVGO components have a correlation of 0.36, but this correlation has only a small effect on total PE variation because of the low volatility of no-growth PE values. Thus, most of the variation of the total PE is due to growth opportunities and, not surprisingly, the PVGO PE and the total PE are highly correlated at 0.998. Both the growth PE and the total PE decrease when risk-free rates and earnings growth increase. The latter correlation is particularly strong at -0.766. High earnings growth by itself increases earnings, which is the denominator of the PE ratio, and causes PE ratios to decrease resulting in the high negative correlation between earnings growth and PE ratios. But, there is another discount rate effect because high earnings growth causes discount rates to significantly increase (see Table 1). This also causes PE ratios to decrease. High payout ratios, as expected, are positively correlated with PE ratios at 0.713. Finally, the latent factor f is negatively correlated with PE ratios because it is only a discount rate factor: by construction PE ratios are high when f is low.

5 Conclusion

We decompose price-earnings (PE) ratios into a no-growth component, which is the perpetuity value of future earnings that are held constant with full payout, and a present value of growth opportunities (PVGO) component, which reflects the growth opportunities and real options a firm has to invest in the future. Both components are valued under a dynamic stochastic environment where risk premiums and earnings growth are stochastic. We find that although discount rates exhibit significant variation, discount rates are highly mean-reverting. This causes the no-growth value of earnings to exhibit relatively little volatility. The PVGO component dominates and accounts for the bulk of the level and variation of PE ratios in data: approximately 80% of the level and 95% of the variance of PE ratios is due to time-varying growth opportunities.

Appendix

A Full and No-Growth Price-Earnings Ratios

All formulae are derived in the online Appendix.

The coefficients a_i and b_i for the PE ratio in equation (10) are given by

$$\begin{aligned} a_{i+1} &= -\delta_0 + a_i + (e_2 + b_i)' \mu + \frac{1}{2} (e_2 + b_i)' \Sigma \Sigma' (e_2 + b_i) \\ b_{i+1} &= -\delta_1 + \Phi' (e_2 + b_i), \end{aligned} \quad (\text{A-1})$$

where e_n is a vector of zero's with a 1 in the n th position. The initial conditions are $a_1 = -\delta_0 + (e_2 + e_3)' \mu + \frac{1}{2} (e_2 + e_3)' \Sigma \Sigma' (e_2 + e_3)$ and $b_1 = -\delta_1 + \Phi' (e_2 + e_3)$.

The coefficients in the no-growth price-earnings ratio, PE_t^{ng} , in equation (11) are given by

$$\begin{aligned} a_{i+1}^* &= -\delta_0 + a_i^* + b_i^{*'} \mu + \frac{1}{2} b_i^{*'} \Sigma \Sigma' b_i^* \\ b_{i+1}^* &= -\delta_1 + \Phi' b_i^*, \end{aligned} \quad (\text{A-2})$$

where a_i^* and b_i^* have initial values $a_1^* = -\delta_0$ and $b_1^* = -\delta_1$.

B Data

The PE ratio defined by S&P is the market value at time t divided by trailing 12-month earnings reported from t to $t - 1$. To back out earnings growth from PE ratios we use the transformation:

$$\exp(g_{t+1}) = \frac{EA_{t+1}}{EA_t} = \frac{PE_t}{PE_{t+1}} \cdot \frac{P_{t+1}}{P_t}, \quad (\text{B-1})$$

where P_{t+1}/P_t is the price gain (capital gain) on the market from t to $t + 1$.

The dividend yield reported by S&P is also constructed using trailing 12-month summed dividends. We compute the log payout ratio using the ratio of the dividend yield, $dy_t = D_t/P_t$ to the inverse PE ratio:

$$\exp(po_t) = \frac{dy_t}{1/PE_t} = \frac{D_t}{EA_t} \quad (\text{B-2})$$

For risk-free rates, r_t^f , we use one-year zero coupon yields expressed as a log return, which are obtained from the Fama CRSP bond files. For macro variables, we express industrial production growth (ip) as a log year-on-year growth rate where the industrial production index is from the St. Louis Federal Reserve. We define the term spread ($term$) as the difference in annual yields between 10-year and 1-year government bonds, which are obtained from CRSP, and the credit spread ($credit$) as the difference in annual yields between Baa-rated and Aaa-rated corporate bonds, which are obtained from the St Louis Federal Reserve.

References

- [1] Ang, A., and J. Liu, 2001, "A General Affine Earnings Valuation Model," *Review of Accounting Studies*, 6, 397-425.
- [2] Bakshi, G., and Z. Chen, 2005, "Stock Valuation in Dynamic Economies," *Journal of Financial Markets*, 8, 115-151.
- [3] Bansal, R., and A. Yaron, 2004, "Risk for the Long Run: A Potential Resolution of Asset Pricing Puzzles," *Journal of Finance*, 59, 1481-1509.
- [4] Bekaert, G., E. Engstrom, and S. Grenadier, 2010, "Stock and Bond Returns with Moody Investors," *Journal of Empirical Finance*, 17, 867-894.
- [5] van Binsbergen, J., and R. S.J. Koijen, 2010, "Predictive Regressions: A Present-Value Approach," *Journal of Finance*, 65, 1439-1471.
- [6] Bodie, Z., A. Kane, and A. J. Marcus, 2009, *Investments*, 8th ed., McGraw-Hill/Irwin, New York, NY.
- [7] Campbell, J. Y., and R. J. Shiller, 1988, "The Dividend-Price Ratio and Expectations of Future Dividends and Discount Factors," *Review of Financial Studies*, 1, 3, 195-228.
- [8] Claus, J., and J. Thomas, 2001, "Equity Premia as Low as Three Percent? Evidence from Analysts' Earnings Forecasts for Domestic and International Stock Markets," *Journal of Finance*, 56, 1629-1666.
- [9] Fama, E. F., and K. R. French, 2002, "The Equity Premium," *Journal of Finance*, 57, 637-659.
- [10] Jagannathan, R., E. R. McGrattan, and A. Scherbina, 2001, "The Declining U.S. Equity Premium," *Quarterly Review Federal Reserve Bank of Minneapolis*, 24, 3-19.
- [11] Miller, M. H., and F. Modigliani, 1961, "Dividend Policy, Growth, and the Valuation of Shares," *Journal of Business*, 34, 411-433.
- [12] Vuolteenaho, T., 2002, "What Drives Firm-Level Stock Returns?" *Journal of Finance*, 58, 233-264.

Table 1: Parameter Estimates

	r^f	g	po	ip	$term$	f
Discount Rate Parameters δ_1						
	0.325 (0.775)	0.381 (0.121)	0.164 (0.088)	-1.283 (0.238)	1.203 (1.728)	1 -
VAR Parameter Φ						
r^f	0.863 (0.089)	0.026 (0.008)	0.012 (0.012)	-0.005 (0.033)	0.088 (0.191)	0 -
g	0.917 (1.385)	0.628 (0.353)	0.650 (0.426)	0.115 (0.362)	3.677 (3.446)	0 -
po	-0.771 (1.292)	-0.514 (0.328)	0.303 (0.415)	0.045 (0.360)	-2.805 (3.131)	0 -
ip	-0.244 (0.237)	0.096 (0.057)	0.071 (0.041)	-0.169 (0.108)	0.908 (0.737)	0 -
$term$	0.021 (0.036)	-0.017 (0.005)	-0.003 (0.007)	-0.025 (0.019)	0.502 (0.092)	0 -
f	0 -	0 -	0 -	0 -	0 -	0.904 (0.003)

Table 2: Variance Decompositions of the PE Ratio

	Data PE	100.0%
r^f		17.8%
g		38.3%
po		65.9%
ip		-38.6%
$term$		7.5%
f		70.5%

Table 3: Correlations of Growth (PVGO) and No-Growth Components of the PE Ratio

	PE no growth	PE PVGO
PE PVGO	0.363	
Data PE	0.421	0.998
r^f	-0.353	-0.426
g	-0.051	-0.766
po	-0.292	0.713
ip	0.114	-0.303
$term$	0.027	0.390
f	-0.903	-0.538

Figure 1: PE Ratios, Payout Ratios, and Dividend Yields

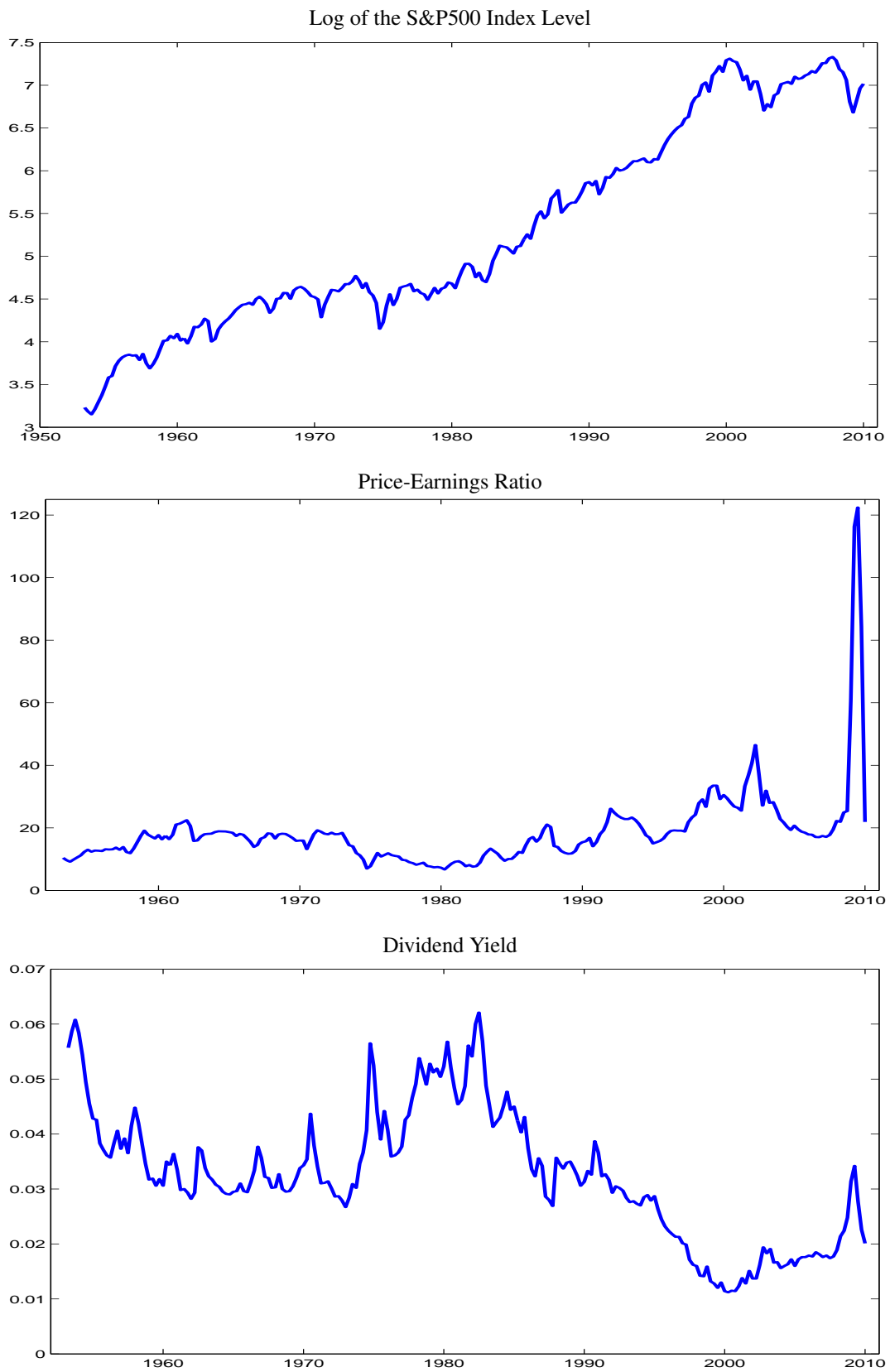


Figure 2: Discount Rates

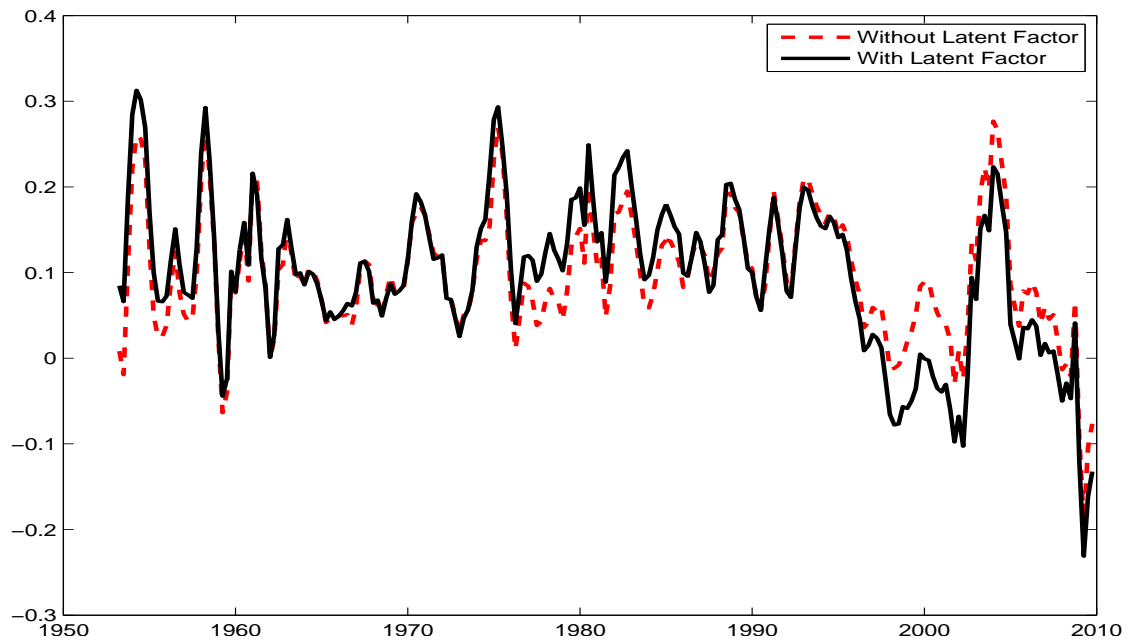


Figure 3: No-Growth and Growth Components of the PE

