

The Price:Earnings Ratio (a.k.a PE ratio)

Calculating The Market PE Ratio

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March, 2026

In this white paper we will build a model to calculate the theoretical market PE ratio and then compare it to the actual market PE ratio.

Our Hypothetical Problem

The table below presents S&P 500 Composite discrete-time averages over the time interval 1900 to 2024...

Description	Value
Average trailing PE ratio (#)	16.40
Average annual total return (%)	9.99
Average annual earnings growth rate (%)	4.99
Average dividend payout ratio (%)	57.10

Question 1: What is the theoretical market PE ratio?

Question 2: Compare the theoretical PE ratio to the actual market PE ratio.

Building Our Model

The definition of the price:earnings ratio is...

$$\text{PE ratio} = \frac{\text{Share price}}{\text{Annualized earnings per share}} \quad (1)$$

Using Equation (1) above, the equation for share price as a function of earnings per share is...

$$\text{Share price} = \text{Annualized earnings per share} \times \text{PE ratio} \quad (2)$$

We will define the variable V_0 to be share price at time zero, the variable E_0 to be annualized earnings per share at time zero, and the variable M to be the price:earnings ratio (a.k.a. PE or share price multiple). Using Equation (2) above, the equation for share price at time zero is...

$$\text{if... } E_0 = \$2.50 \text{ ...and... PE} = 17.50 \text{ ...then... } V_0 = \$2.50 \times 17.50 = \$43.75 \quad (3)$$

We will define the variable D_t to be dividends per share paid at the end of time t where t is an integer value representing the year number. We will also define the variable k to be the risk-adjusted cost of capital (a.k.a. discount rate). The equation for share price today as a function of the discounted value of expected dividends to be received in the future is...

$$V_0 = \frac{D_1}{(1+k)^1} + \frac{D_2}{(1+k)^2} + \frac{D_3}{(1+k)^3} + \dots + \frac{D_\infty}{(1+k)^\infty} \text{ ...where... } t \in \{0, 1, 2, 3, \dots, \infty\} \quad (4)$$

We want to make dividends paid a function of after-tax earnings per share. We will define E_t to be earnings per share at the end of time t , the variable g to be the annualized earnings growth rate, and the variable P to be the payout ratio (i.e. percent of earnings paid out as dividends). Using Equation (4) above, the equation for dividends per share paid at the end of time t is...

$$D_t = P E_t \text{ ...where... } E_t = E_0 (1+g)^t \quad (5)$$

Using Equation (5) above, we can rewrite Equation (4) above as...

$$V_0 = P E_0 \frac{(1+g)^1}{(1+k)^1} + P E_0 \frac{(1+g)^2}{(1+k)^2} + P E_0 \frac{(1+g)^3}{(1+k)^3} + \dots + P E_0 \frac{(1+g)^\infty}{(1+k)^\infty} \quad (6)$$

Note that we can rewrite Equation (6) above via the following summation...

$$V_0 = P E_0 \sum_{t=1}^{\infty} \theta^t \text{ ...where... } \theta = \frac{1+g}{1+k} \quad (7)$$

The summation in Equation (7) above is an infinite series. The solution to that infinite series is...

$$\sum_{t=1}^{\infty} \theta^t = \frac{\theta}{1-\theta} \text{ ...given that... } 0 < \theta < 1 \text{ (See Wikipedia [List of mathematical series])} \quad (8)$$

Using the definition of the variable theta in Equation (7) above, the solution to the infinite series in Equation (8) above is...

$$\sum_{t=1}^{\infty} \theta^t = \frac{\theta}{1-\theta} = \frac{1+g}{1+k} \bigg/ \left(1 - \frac{1+g}{1+k}\right) = \frac{1+g}{k-g} \quad (9)$$

Using Equation (9) above, we can rewrite Equation (7) above as...

$$V_0 = P E_0 \sum_{t=1}^{\infty} \theta^t = E_0 \frac{P(1+g)}{k-g} \quad (10)$$

Note that using Equations (2), (3) and (10) above, the equation for the PE ratio is...

$$\text{if... } V_0 = E_0 \times \text{PE ratio} \text{ ...then... PE ratio} = \frac{P(1+g)}{k-g} \text{ ...given that... } 0 < g < k < 1 \quad (11)$$

Answers To Our Hypothetical Problem

Question 1: What is the the theoretical market PE ratio?

Using Equation (11) above and the market averages in the table above, the answer to the question is...

$$\text{PE ratio} = \frac{P(1+g)}{k-g} = \frac{0.5710 \times (1+0.0449)}{0.0999 - 0.0449} = 12.00 \text{ ...given that... } 0 < 0.0449 < 0.0999 < 1 \quad (12)$$

Question 2: Compare the theoretical and actual market PE ratios.

Using Equation (12) above and the market averages in the table above, the answer to the question is...

$$\text{PE difference} = 16.40 - 12.00 = 4.40 \quad (13)$$

This difference can be attributed to non-operating cash and cash equivalents, other non-operating assets, the value of non-interest-bearing liabilities, and the interest-bearing debt tax shield, all of which are additions to company value. These additions to company value are not accounted for in the PE ratio Equation (11) above.