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Stock Prices, "News" and the Efficient Markets Hypothesis

The Present Value Model Approach to Asset Pricing

The textbook expresses the stock price as the present discounted value of the dividend paid and the price of the stock next period.

$$P_t = \frac{D_{t+1}}{1+i} + \frac{P_{t+1}}{1+i} \qquad [8.1]$$

In reality, we don't know the price next period. Rather we have an expectation of the price next period, and for now we assume Rational Expectations (such that the market expectation is the mathematical conditional expectation). Hence the expectations operator refers to the conditional mathematical expectations operator. For one-period, the price today equals the discounted dividend and the expected price tomorrow:

$$P_t = \frac{D_{t+1}}{1+i} + \frac{E_t P_{t+1}}{1+i} \qquad [8.1']$$

Where for simplicity, the interest rate used to discount the future is a constant i, and $E_t(Z_{t+1})$ = $E(Z$ | information available at time t+1). Assume at time t, that D_t is known.

Note that the price next period is given by:

$$P_{t+1} = \frac{D_{t+2}}{1+i} + \frac{E_{t+1} P_{t+2}}{1+i} \qquad [8.2']$$

Substituting into [8.1'] yields:

$$P_t = \frac{D_{t+1}}{1+i} + \frac{E_t(E_{t+1} D_{t+2})}{(1+i)(1+i)} + \frac{E_t(E_{t+1} P_{t+2})}{(1+i)(1+i)} \qquad (1)$$

Note that by the "Law of Iterated Expectations", *viz.*,

$$E_t(E_{t+1}(Z_{t+2})) = E_t Z_{t+2}$$

Equation (1) becomes:

$$P_t = \frac{D_{t+1}}{1+i} + \frac{E_t D_{t+2}}{(1+i)^2} + \frac{E_t P_{t+2}}{(1+i)^2} \qquad [8.3']$$

One can continue to substitute out for P_{t+i} to obtain the **Generalized Dividend Valuation Model:**

$$P_t = \frac{D_{t+1}}{1+i} + \frac{E_t D_{t+2}}{(1+i)^2} + \ldots + \frac{E_t D_{t+n}}{(1+i)^n} + \frac{E_t P_{t+n}}{(1+i)^n} \qquad [8.4']$$

Note that this expression implies, *under certain conditions*:

$$P_t = \frac{D_{t+1}}{1+i} + \frac{E_t D_{t+2}}{(1+i)^2} + \frac{E_t D_{t+3}}{(1+i)^3} + \ldots + \frac{E_t D_{t+\infty}}{(1+i)^\infty} = \sum_{n=1}^{\infty} \frac{E_t D_{t+n}}{(1+i)^n} \qquad (2)$$

So that the price today equals the present discounted value of dividends from the present to the infinite future. One "certain condition" is that we rule out "**bubbles**". That is, it is assumed that

$$\lim_{n \to \infty} \frac{E_t P_{t+n}}{(1+k_e)^n} = 0$$

It's hard to test (2), even assuming away bubbles, because expectations are not observable. How can one simplify the expression to get something concrete?

The **Gordon Growth Model** assumes that dividends are expected to grow deterministically at rate *g*, such that $D_{t+n} = (1+g)^n \times D_t$ (which is equation [8.6]). Substituting [8.6] into (2) yields, for n < ∞:

$$P_t = \frac{D_t \times (1+g)^1}{(1+i)^1} + \frac{D_t \times (1+g)^2}{(1+i)^2} + \ldots + \frac{D_t \times (1+g)^n}{(1+i)^n} \qquad [8.7]$$

If one allows *n* to go to infinity:

$$P_t = \frac{D_t \times (1+g)^1}{(1+i)^1} + \frac{D_t \times (1+g)^2}{(1+i)^2} + \ldots + \frac{D_t \times (1+g)^\infty}{(1+i)^\infty} \qquad (3)$$

$$P_t = D_t \times \left[\frac{(1+g)^1}{(1+i)^1} + \frac{(1+g)^2}{(1+i)^2} + \ldots + \frac{(1+g)^\infty}{(1+i)^\infty} \right] = \frac{D_t (1+g)}{(i-g)} \qquad (4)$$

In general, *D* will not grow in a smooth deterministic fashion, nor will *i* be constant. As a consequence, the fluctuations in prices will not move one for one with contemporaneous dividends.

The previous calculations assume that the interest rate used to discount the future values is constant, and equal to a risk free rate. In general, the interest rate used is the sum of the risk free rate and a risk premium (*rf* and *rp*, respectively, in the textbook). Substituting:

$$P_t = \frac{D_t (1+g)}{(rf + rp - g)} \qquad (5)$$

In the below figures, monthly data from Robert Shiller's website (http://www.econ.yale.edu/~shiller/data/ie_data.xls) are used to highlight the relationships between stock prices, dividends and interest rates. In Figure 1, real (CPI deflated) stock prices and dividends are shown; and in Figure 2 real prices and (nominal) ten year Treasury interest rates (a proxy for the risk free rate).

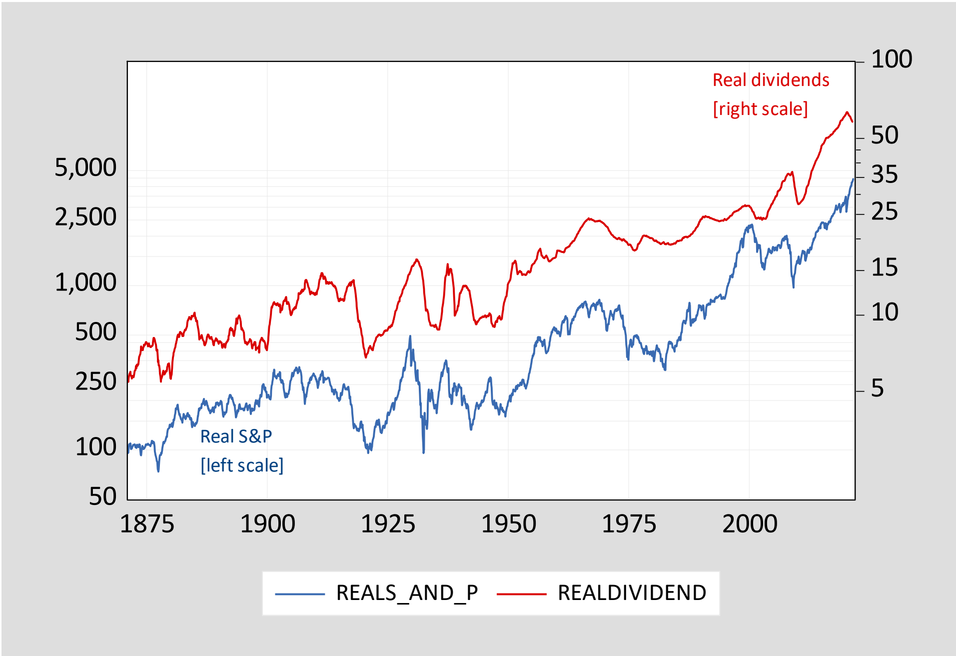

Figure 1: Real (CPI deflated) Standard and Poor index (left scale, log), and real dividends (right scale, log). Source: Robert Shiller, http://www.econ.yale.edu/~shiller/data/ie_data.xls accessed 10/8/2019.

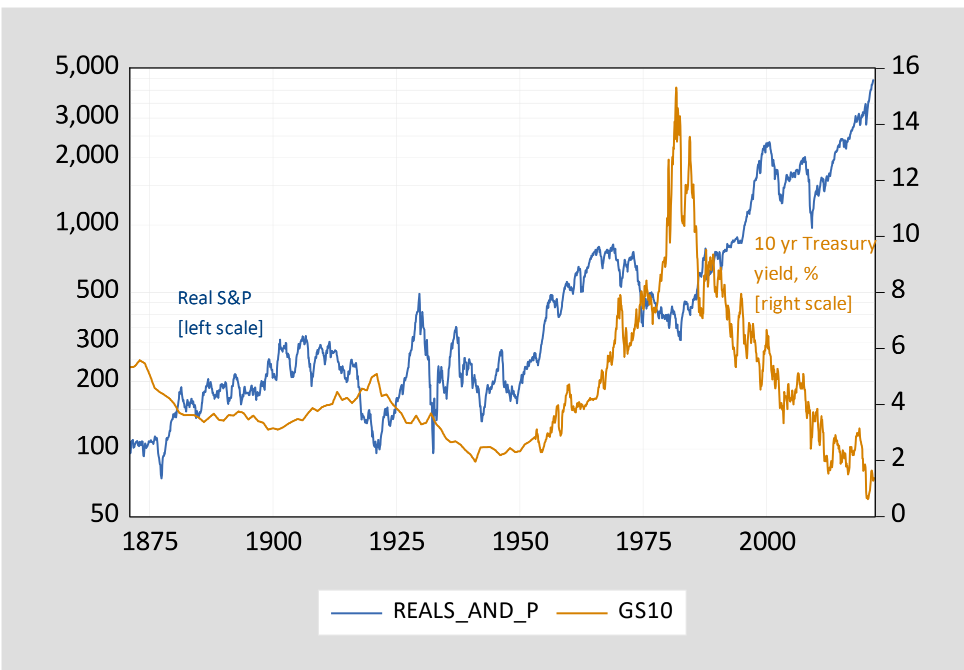

Figure 2: Real (CPI deflated) Standard and Poor index (left scale, log), and ten year interest rate (right scale). Source: Robert Shiller, http://www.econ.yale.edu/~shiller/data/ie_data.xls , accessed 10/8/2019.

As predicted, the stock price index covaries positively with dividends (dividends are highly serially correlated, so a movement up in dividends persists), and is negatively related to the interest rate. Note that dividing both sides of equation (5) by D_t leads to the relationship that the price/dividend ratio is inversely related to the interest rate (minus the growth rate of dividends).

$$\frac{P_t}{D_t} = \left[\frac{(1+g)^1}{(1+rf+rp)^1} + \frac{(1+g)^2}{(1+rf+rp)^2} + \ldots + \frac{(1+g)^\infty}{(1+rf+rp)^\infty} \right] = \frac{1}{(rf+rp-g)} \qquad (6)$$

The posited inverse relationship is shown in Figure 3.

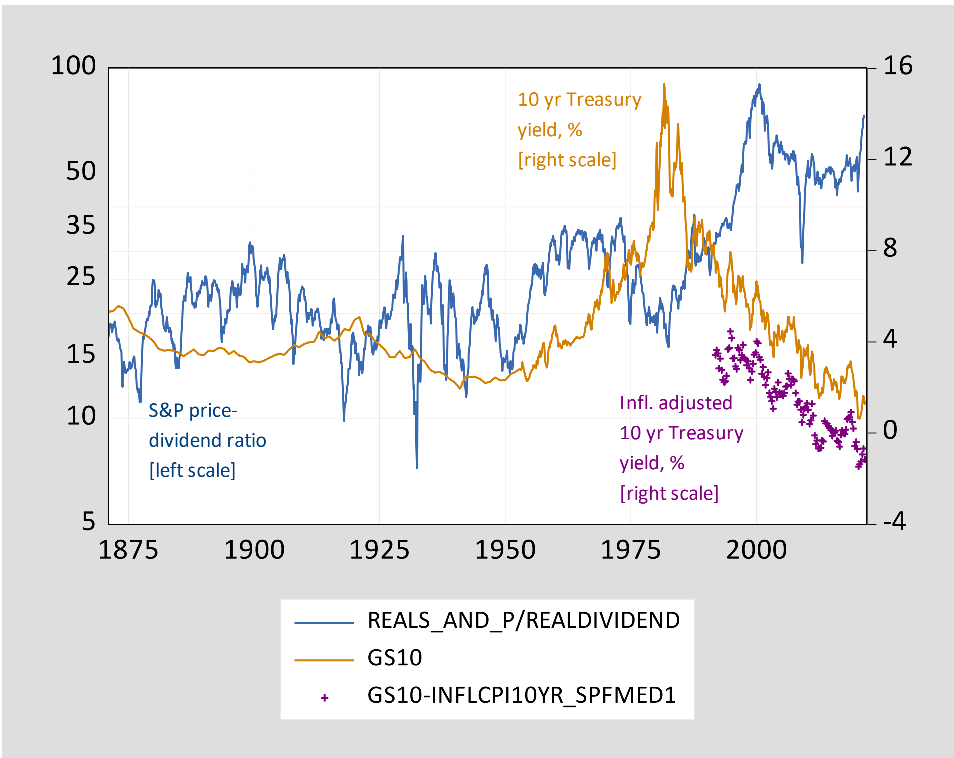

Figure 3: Standard and Poor price to dividend ratio (left scale), and ten year interest rate (right scale). Source: Robert Shiller, http://www.econ.yale.edu/~shiller/data/ie_data.xls accessed 10/12/2018.

Notice that the relationship is not perfectly inverse. That's because (1) dividends aren't typically expected to grow at a constant exponential rate, and (2) the Treasury yield does not incorporate a risk premium for holding equities.

"News"

Let's return to a risk neutral model. Recall the present value of a stock is given by:

$$P_t = \frac{D_{t+1}}{1+i} + \frac{E_t P_{t+1}}{1+i} \qquad [8.1']$$

$$E_t P_{t+1} = \frac{E_t D_{t+2}}{1+i} + \frac{E_t(E_{t+1}P_{t+2})}{1+i} = \frac{E_t D_{t+2}}{1+i} + \frac{E_t P_{t+2}}{1+i} \qquad (7)$$

The last term after the second equal sign in (7) obtains by the "Law of Iterated Expectations", *viz.*,

$$E_t(E_{t+1}(Z_{t+2})) = E_t Z_{t+2}$$

Now decompose the change in the price of the asset:

$$P_{t+1} - P_t \equiv (E_t P_{t+1} - P_t) + [(P_{t+1} - E_t P_{t+1})] \qquad (8)$$

The first term is the expected portion of the price change. The second term in the brackets is the unexpected portion. This second portion in square brackets can be further broken up.

$$P_{t+1} - P_t = (E_t P_{t+1} - P_t) + \left[\frac{D_{t+2} - E_t D_{t+2}}{(1+rp+rf)} + \frac{E_{t+1}P_{t+2} - E_t P_{t+2}}{(1+rp+rf)} \right] \qquad (9)$$

"News" includes the dividends announced for period t+2. It is unforecastable. This news may also affect people's expectations regarding *D* in the future, and hence *P* in the future (which in turn affects expectations of *P* in period t+2). Hence, new information directly results in a new price, and revisions in expectations. Notice the second term in the square bracket is

$$\frac{E_{t+1}P_{t+2} - E_t P_{t+2}}{(1+rp+rf)}$$

which is the change in the expectations regarding the asset price in period t+2, based upon what the market knew in period t+1 versus what it knew in period t.

Note that other "news" that doesn't affect *D* in period t+2 could still affect expected asset prices in the future, and hence the asset price today.

An example: The stock market

Goldman Sachs is sued by SEC, announcement approx. 10:30am, on April 16, 2010.

What equation (2) says is that the price will evolve as expectations of dividends into the future change over time.

$$P_t = \frac{D_{t+1}}{1+(rf+rp)} + \frac{E_t D_{t+2}}{(1+(rf+rp))^2} + \frac{E_t D_{t+3}}{(1+(rf+rp))^3} + \ldots + \frac{E_t D_{t+\infty}}{(1+(rf+rp))^\infty} = \sum_{n=1}^{\infty} \frac{E_t D_{t+n}}{(1+(rf+rp))^n} \quad (2)$$

Those dividend streams depend in part upon the earnings that firms are expected to earn in the future. As the economy looks more likely to slow down, expectations of earnings (and hence dividends) are likely to be revised downward.

Moreover, there is no reason the required return on equity has to remain constant. If it varies over time, then (2) becomes:

$$P_t = \frac{D_{t+1}}{1+(rf_t+rp_t)} + \frac{E_t D_{t+2}}{(1+(rf_t+rp_t))(1+(rf_{t+1}+rp_{t+1}))} +$$

$$\frac{E_t D_{t+3}}{(1+(rf_t+rp_t))(1+(rf_{t+1}+rp_{t+1}))(1+(rf_{t+2}+rp_{t+2}))} + \ldots + \frac{E_t D_{t+\infty}}{(1+(rf_t+rp_t))\ldots(1+(rf_{t+\infty-1}+rp_{t+\infty-1}))}$$

(2')

To the extent that the required return varies with the interest rate (say on the 3 month Treasury) and risk aversion, an additional source of variation is introduced into the stock price.

Efficient Markets Hypothesis

In the above discussion, I have assumed that the subjective market expectation of future dividends and prices equals the mathematical expectations. This assumption is called the rational expectations hypothesis. One implication of rational expectations is:

$$X_t = E_{t-1} X_t + u_t$$
$$u_t \_ iid(0, \sigma_u)$$

That is, the actual realization of *X* equals the expectation of *X* based on time t-1 information, plus an unforecastable random error, *u*.

Consider for instance if dividends were paid only every year, and each period was one day. Then equation (1) becomes:

$$P_t = \frac{E_t P_{t+1}}{1+(rf+rp)}$$

Use the definition of rational expectations above, and assume log-normality of the error term:

$$p_t = E_t p_{t+1} - \ln(1+rf+rp)$$
$$p_{t+1} = p_t + (rf+rp) + \widetilde{u}_{t+1}$$

So stock prices follow a random walk (with drift). It is not quite right to say the best predictor of tomorrow's stock price is today's. Rather there is a small predictable component (k_e), which from one day to another is quantitatively very small.