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THE DETERMINANTS OF THE VARIABILITY OF STOCK MARKET PRICES

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ABSTRACT

Historical movements in stock price indexes may be attributed to new information either about future real dividends or about real interest rates used to discount these dividends to today's price. Earlier work suggests that real dividends do not move enough to justify the price index movements. This paper provides evidence that the stock price movements over the last century can be better justified in terms of real interest rate movements. Movements in real interest rates can be inferred from the marginal rate of substitution evidenced by consumption data.

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The Determinants of the Variability of Stock Market Prices

by

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The most familiar interpretation for the large and unpredictable swings that characterize common stock price indices is that price changes represent the efficient discounting of "new information." It is remarkable given the popularity of this interpretation that it has never been established what this information is about. Recent work by Robert Shiller, and Stephen LeRoy and Richard Porter, has shown evidence that the variability of stock price indices cannot be accounted for by information regarding future dividends since dividends just do not seem to vary enough to justify the price movement. These studies assume a constant discount factor. In this paper, we consider whether the variability of stock prices can be attributed to information regarding discount factors (i.e. real interest rates), which are in turn related to current and future levels of economic activity.

The appropriate discount factor to be applied to dividends which are received k years from today is the marginal rate of substitution between consumption today and consumption k periods from today. We use historical data on per capita consumption from 1890-1979 to estimate the realized value of these marginal rates of substitution.

Robert Hall also studied these marginal rates of substitution and concluded that consumption is a random walk. We show that if current consumption and dividends are the best predictors of future consumption and dividends in Hall's sense, then the discount factor applied to stock prices would not vary. The variability

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$(P_{it+1} + D_{it+1})/P_{it}$ is the return (or rather one plus the rate of return as it is usually calculated). Note that the expectation in (2) conditional on information I_t is always 1. Hence it does not depend on I_t. Therefore, it equals the unconditional or simple expectation

$$(3) \qquad 1 = E(R_{it}S_t) \quad .$$

Thus, the proper stochastic interpretation of the familiar two-period diagram is that the expected product of the uncertain return and the uncertain marginal rate of substitution is one. This means that $E(R_{it})$ needn't equal the subjective rate of time preference nor need it be the same for all assets ("expected profit opportunities" may exist). Instead, (3) says that a weighted expectation of returns, with weights corresponding to marginal rates of substitution, is the same for all assets. Returns which come in periods of low marginal utility of consumption (i.e. when consumption is high) are given little weight, because they do little good in terms of utility. Returns which come in periods of high marginal utility are given a lot of weight. The same expression can also be written another way, using the fact that the expected product of two variables is the product of their means plus their covariance:

$$(4) \qquad E(R_{it}) = E(S_t)^{-1} \cdot (1 - \mathrm{cov}(R_{it}, S_t)) \quad .$$

Equation (4) states that the expected return of an asset depends on the covariance of the asset's return with the marginal rate of substitution. An asset is very "risky" if its payoff has a high negative covariance with S. (Douglas Breeden has recently persuasively argued for the use of consumption correlatedness as the appropriate measure of risk.)

The theory of asset returns embodied in each of expressions (1) through (4) is very powerful because it can be applied so generally. It holds for any asset, or

Figure 1 shows a plot of P_t from 1889-1979, where P_t is the annual average Standard and Poor Composite Stock Price Index divided by the consumption deflator. On the same figure, we plot the perfect foresight real price P_t^* for A=0 and A=4 using (6) and (7), where we use actual realized real annual dividends for the Standard and Poor series, the Kuznets-Kendrick-US NIA per capita real consumption on nondurables and services and the terminal condition $P^*_{1979} = P_{1979}$. For each A, we generate a value of β so that (3) holds, as estimated by the sample mean. The case A=0 is revealing; this is the case of risk neutrality, and of a constant discount factor. Notice that with a constant discount factor, P_t^* just grows with the trend in dividends; it shows virtually none of the short-term variation of actual stock prices. The larger A is, the bigger the variations of P_t^* and A=4 was shown here because, for this A, P and P* have movement of very similar magnitude. Irwin Friend and Marshall Blume estimated A to be about 2 under the assumption that the only stochastic component of wealth is stock returns. Irwin Friend and Joel Hasbrouck estimated A to be about 6 when stock returns and human capital are the stochastic components of wealth. We also computed a P* series using after' tax returns. It did not look much different from the P* shown here in the first half of the sample when income taxes were generally unimportant, and did not seem to fit P any better in the second half.

The rough correspondence between P* and P (except for the recent data) shows that if we accept a coefficient of relative risk aversion of 4, we can to some extent reconcile the behavior of P with economic theory even under the assumption that future price movements are known with certainty. In a world of certainty, the marginal rate of substitution S_t would equal the inverse of one plus the real interest rate, r_t. Hence our equilibrium condition becomes $(P_{t+1} + D_{t+1}) \div P_t = 1+r_t$. Thus it can be shown that real stock prices as well as real prices of other assets whose dividend is stable in real terms will rise dramatically over periods when real interest rates are very high. Real interest rates will be high when C_{t+1} is high relative to C_t, e.g. in periods of depression when C_t is abnormally low.

Hence it is an equilibrium for P_t to be low (relative to P_{t+1}) because otherwise people will desire to dissave (e.g., by selling stock at t) in order to maintain their consumption level. Movements in real interest rates which are necessary to equilibrate desired savings to actual savings will lead to changes in stock prices even if dividends are unchanged. It is these movements which are brought out in the figure when P* with A=4 is compared with P* with A=0.

The correlation between P* and P is perhaps not altogether surprising, given the correlation between the stock market and aggregate economic activity over the business cycle noted long ago by many people, e.g. Arthur Burns and Wesley Mitchell. However, P_t^* is not merely a proxy for aggregate economic activity or consumption at time t. If we assume, as an approximation, that dividends follow a growth path $D_t = D_o\delta^t$ and if we set $n=\infty$ in (6) to ignore the terminal price, then P_t^* is given by: $P_t^* = D_o\delta^t[C_t^A \sum_{k=0}^{\infty} (\beta\delta)^K C_{t+k}^{-A}]$. This says that P_t^* follows a growth path times the ratio of C_t^A to a weighted harmonic average of future C^A. The weights decline exponentially into the future. Thus, for example, P* declines gradually between 1907 and 1919 not because consumption declined, since real per capita consumption remained more or less level over this period, but because the gap between current consumption and the longer-run outlook widened. In other words, P* fell at this time because of perfect foresight individual, knowing his economic fortune would eventually improve following the war period, wished to try to smooth his consumption over this period. This kind of relationship between P and C would not have been visible by looking at raw stock price and economic activity index series alone, as the earlier scholars did. On the other hand, the short-run correspondence between P and P* around such episodes as the panics of 1893 or 1907 was in effect noted by these authors.

Our construction implies that P* (as well as P) is a leading indicator of future levels of economic activity, but it does not suggest the conventional notion of a fixed lead of a few months to a year between P and aggregate economic ments in consumption are not forecastable by consumers. To see this, write the jth term in the summation in (5) as $E(\beta^j u'(C_{t+j})/u'(C_t)| I_t)E(D_{t+j}| I_t) + \text{cov}(\beta^j u'(C_{t+j})/u'(C_t), D_{t+j}| I_t)$. If neither the expectation of $\beta^j u'(C_{t+j})/u'(C_t)$ nor its covariance with dividends is forecastable (depends on I_t), then this term varies only due to changes in the expectation of D_{t+j}, i.e. due to information about dividends. If, moreover, $E(\beta^j u'(C_{t+j})/u'(C_t)| I_t) = \gamma^j$ (as might be suggested by Hall's random walk hypothesis), then P_t equals $E(\hat{P}^*_t| I_t)$ where $\hat{P}^*_t = \sum \gamma^j D_{t+j}$ (plus a deterministic term due to the covariance). $\hat{P}^*_t$ has a constant discount factor and is proportional to P^* in Figure 1 with A=0. Because P^*_t with A=0 fails the variance test as mentioned previously, we tend to reject models with constant discount factors. Hence we conclude that consumption changes are forecastable. This implies that expected real interest rates vary (contrary to the claims of E. Fama and others).

This conclusion does not contradict Robert Hall's assertions that (i) to an <u>econometrician</u> who does not know as much as consumers, the marginal utility of consumption is a random walk and (ii) that income may be a proxy for lagged consumption in econometric models which have shown that consumption is very sensitive to income. The fact that stock prices vary so much with consumption suggests that consumers have more information about consumption than is contained in current consumption, and this leads expected real interest rates to vary with information.

III. Further Research

We have some preliminary results on the estimation of A and β. Estimates of both parameters can be derived using expression (3) for two different assets, which we took as stocks and short-term bonds. Unfortunately, the estimates of A for the more recent subperiods seem implausibly high. This breakdown of the model mirrors the divergence between P^* and P since the early 1950's, as well as the extremely low real return on short-term bond rates in this period. There was an

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