Mphil Subject 301

Market Efficiency and Stock Market Predictability

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1 Stock Return Regressions

$$R_{t+1} - r_t = a + b_1 x_{1t} + b_2 x_{2t} + ... + b_k x_{kt} + \varepsilon_{t+1}, \quad (1)$$

R_{t+1} is the one-period (day, week, month,..) holding return on an stock index, such as FTSE, Dow Jones or Standard and Poor 500, defined by

$$R_{t+1} = (P_{t+1} + D_{t+1} - P_t)/P_t, \quad (2)$$

P_t is the stock price at the end of the period and D_{t+1} is the dividend paid out over the period t to $t+1$, and x_{it} , $i = 1, 2, ..., k$ are the factors/variables thought to be important in predicting stock returns. Finally, r_t is the return on the government bond with one-period to maturity (the period to maturity of the bond should exactly be the same as the holding period of the stock). $R_{t+1} - r_t$ is known as the excess return (return on stocks in excess of the return on the safe asset). Note also that r_t would be known to the investor/trader at the end of period t, before the price of stocks, P_{t+1}, is revealed at the end of period $t+1$.

Examples of possible stock market predictors are past changes in macroeconomic variables such as interest rates, inflation, dividend yield (D_t/P_{t-1}), price earnings ratio, output growth, and term premium (the difference in yield of a high grade and a low grade bond such as AAA rated minus BAA rated bonds).

For individual stocks the relevant stock market regression is the capital asset pricing model (CAPM), augmented with potential predictors:

$$R_{i,t+1} = a_i + b_{1i}x_{1t} + b_{2i}x_{2t} + ... + b_{ki}x_{kt} + \beta_i R_{t+1} + \varepsilon_{i,t+1}, \quad (3)$$

where $R_{i,t+1}$ is the holding period return on asset i (shares of firm i), defined similarly as R_{t+1}. The asset-specific regressions (3) could also include firm specific predictors, such as R_{it} or its higher order lags, book-to-market value or size of firm i. Under market efficiency, as characterized by CAPM,

$$a_i = 0, b_{1i} = b_{2i} = ... = b_{ki} = 0.$$

Only the "betas", β_i, will be significantly different from zero. Under CAPM, the value of β_i captures the risk of holding the share i with respect to the market.

2 Market Efficiency and Stock Market Predictability

It is often argued that if stock markets are efficient then it should not be possible to predict stock returns, namely that none of the variables in the stock market regression (1) should be statistically significant. Some writers have even gone so far as to equate stock market efficiency with the non-predictability property. But this line of argument is not satisfactory and does not help in furthering our understanding of how markets operate. The concept of market efficiency needs to be defined separately from predictability. In fact, it is easily seen that stock market returns will be non-predictable only if market efficiency is combined with risk neutrality.

2.1 Risk Neutral Investors

Suppose there exists a risk free asset such as a government bond with a known payout. In such a case an investor with an initial capital of £A_t, is faced with two options:

- Option 1: holding the risk-free asset and receiving
$$\pounds(1 + r_t)A_t,$$
at the end of the next period,
- Option 2: switching to stocks by purchasing A_t/P_t shares and holding them for one period and expecting to receive
$$\pounds\,(A_t/P_t)\,(P_{t+1} + D_{t+1}),$$
at the end of period $t + 1$.

A risk-neutral investor will be indifferent between the certainty of $\pounds(1 + r_t)A_t$, and the his/her expectations of the uncertain payout of option 2. Namely, for such a risk neutral investor

$$(1 + r_t)A_t = E\left[(A_t/P_t)\left(P_{t+1} + D_{t+1}\right)|\mathcal{I}_t\right], \tag{4}$$

where $\mathcal{I}_t$ is the investor's information at the end of period t. This relationship is called the "Arbitrage Condition".

Using (2) we now have

$$P_{t+1} + D_{t+1} = P_t\left(1 + R_{t+1}\right),$$

and the above arbitrage condition can be simplifies to

$$E\left[\left(1 + R_{t+1}\right)|\mathcal{I}_t\right] = (1 + r_t),$$

or

$$E\left(R_{t+1} - r_t\left|\mathcal{I}_t\right.\right) = 0. \tag{5}$$

This result establishes that if the investor forms his/her expectations of future stock (index) returns taking account of all market information efficiently, then the excess return, $R_{t+1} - r_t$, should not be predictable using any of the market information that are available at the end of period t. Notice that r_t is known at time t and is therefore included in $\mathcal{I}_t$. Hence, under the joint hypothesis of market efficiency and risk neutrality we must also have $E\left(R_{t+1}\left|\mathcal{I}_t\right.\right) = r_t$.

The above set up can also be used to derive conditions under which asset prices can be characterised as a random walk model. Suppose, the risk free rate, r_t, in addition to being known at time t, is also constant over time. Then using (4) we can also write

$$P_t = \left(\frac{1}{1+r}\right)\left(E\left[\left(P_{t+1} + D_{t+1}\right)\left|\mathcal{I}_t\right.\right]\right),$$

or

$$P_t = \left(\frac{1}{1+r}\right)\left[E\left(P_{t+1}\left|\mathcal{I}_t\right.\right) + E\left(D_{t+1}\left|\mathcal{I}_t\right.\right)\right].$$

Under the rational expectations hypothesis and assuming that the “transversality condition”

$$\lim_{j\to\infty}\left(\frac{1}{1+r}\right)^j E\left(P_{t+j}\left|\mathcal{I}_t\right.\right) = 0$$

holds we have the familiar result

$$P_t = \sum_{j=1}^{\infty}\left(\frac{1}{1+r}\right)^j E\left(D_{t+j}\left|\mathcal{I}_t\right.\right),$$

that equates the level of stock price to the present discounted stream of the dividends expected to occur to the asset over the infinite future. The transversality condition rules out rational speculative bubbles and is satisfied if the asset prices are not expected to rise faster than the exponential decay rate determined by the discount factor, $0 < 1/(1+r) < 1$. It is now easily seen that if D_t follows a random walk so will P_t. For example, suppose

$$D_t = D_{t-1} + \varepsilon_t,$$

where ε_{t+1} is a white noise process. Then

$$E\left(D_{t+j}\left|\mathcal{I}_t\right.\right) = D_t,$$

and

$$P_t = \frac{D_t}{r}.$$

Therefore, we also have

$$P_t = P_{t-1} + u_t,$$

where $u_t = \varepsilon_t/r$.

The random walk property holds even if $r = 0$, since in such a case it would be reasonable to expect no dividends are also paid out, namely $D_t = 0$. In this case the arbitrage condition becomes

$$E\left(P_{t+1}\left|\mathcal{I}_t\right.\right) = P_t, \tag{6}$$

which is satisfied by the random walk model but is in fact more general than the random walk model. An asset price that satisfies (6) is said to be a martingale process. Random walk processes with zero drift are martingale processes but not all martingale processes are random walks. For example, the price process

$$P_{t+1} = P_t + \lambda\left\{\left(\Delta P_{t+1}\right)^2 - E\left[\left(\Delta P_{t+1}\right)^2\left|\mathcal{I}_t\right.\right]\right\} + \varepsilon_t,$$

where ε_t is a white noise process is a martingale process with respect to the information set $\mathcal{I}_t$, but it is clearly not a random walk process, unless $\lambda = 0$.

2.2 Risk Averse Investors

Risk neutrality is a behavioral assumption and need not hold even if all market information is processed efficiently by all the market participants. A more reasonable way to proceed is to allow some or all the investors

to be risk averse. In this more general case the certain pay out, $(1 + r_t)A_t$, and the expectations of the uncertain pay out, $E\left[\left(A_t/P_t\right)\left(P_{t+1} + D_{t+1}\right)|\mathcal{I}_t\right]$, will not be the same and differ by a (possibly) time-varying risk premium which could also vary with the level of the initial capital, A_t. More specifically, we have
$E\left[\left(A_t/P_t\right)\left(P_{t+1} + D_{t+1}\right)|\mathcal{I}_t\right] = (1+r_t)A_t + \lambda_t A_t$, where λ_t is the premium per £ of invested capital required (expected) by the investor. It is now easily seen that

$$E\left(R_{t+1} - r_t\,|\mathcal{I}_t\right) = \lambda_t,$$

and it is no longer necessary true that under market efficiency excess returns are non-predictable. The extent to which excess returns can be predicted will depend on the existence of a historically stable relationship between the risk premium, λ_t, and the macro and business cycle indicators such as changes in interest rates, dividends and various business cycle indicators.

Market inefficiencies provide further sources of stock market predictability by introducing a wedge between a "correct" ex ante measure of $E\left(R_{t+1} - r_t \left|\mathcal{I}_t\right.\right)$, and its estimate by market participants. Denoting the latter by $\hat{E}\left(R_{t+1} - r_t \left|\mathcal{I}_t\right.\right)$ we have

$$E\left(R_{t+1} - r_t \left|\mathcal{I}_t\right.\right) = \lambda_t + \xi_t,$$

where

$$\xi_t = E\left(R_{t+1} \left|\mathcal{I}_t\right.\right) - \hat{E}\left(R_{t+1} \left|\mathcal{I}_t\right.\right),$$

and ξ_t measures the extent to which errors are made by market participants in predicting stock returns. In practice, $\hat{E}\left(R_{t+1} \left|\mathcal{I}_t\right.\right)$ is likely to be a weighted "average" of market participants' returns expectations (formed possibly with respect to different informations, all being the sub-set of $\mathcal{I}_t$). The weights will be determined by the investor's market share (positive if they are long and negative if they are short). Similarly, λ_t, is the weighted average of the risk premium (per £ invested) of the different market participants.

3 Evidence of Stock Market Predictability

Economists have long been fascinated by the sources of variations in the stock market. By the early 1970's a consensus had emerged among financial economists suggesting that stock prices could be well approximated by a random walk model and that changes in stock returns were basically unpredictable. Fama (1970) provides an early, definitive statement of this position. Historically, the 'random walk' theory of stock prices was preceded by theories relating movements in the financial markets to the business cycle. A prominent example is the interest shown by Keynes in the variation in stock returns over the business cycle. According to Skidelsky (1992) "Keynes initiated what was called an 'Active Investment Policy', which combined investing in real assets - at that time considered revolutionary - with constant switching between short-dated and long-dated securities, based on predictions of changes in the interest rate" (Skidelsky (1992, p. 26)).

Recently, a large number of studies in the finance literature have confirmed that stock returns can be predicted to some degree by means of interest rates, dividend yields and a variety of macroeconomic variables exhibiting clear business cycle variations. While the vast majority of these studies have looked at the US stock market, an emerging literature has also considered the UK stock market.

US Studies include Balvers,Cosimano and MacDonald (1990), Breen, Glosten and Jagannathan (1990),Campbell (1987), Fama and French (1989), Ferson and Harvey (1993), and Pesaran and Timmermann (1994, 1995). See Granger (1992) for a survey of the methods and results in the literature

UK Studies include Clare, Thomas and Wickens (1994), Clare, Psaradakis and Thomas (1995), Black and Fraser (1995), and

Pesaran and Timmermann (2000).

4 Exercise

The file UKUS.fit contains monthly observations on UK and US economies. Using the available data, investigate the extent to which stock markets in UK and US could have been predicted during 1990's.

5 Pitfalls and Problems

- Data mining/Data snooping
- Structural change and model instability
- Transaction costs and market predictability
- Market volatility and learning

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