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Why the CAPM is Half-Right and Everything Else is Wrong

The global financial crisis has caused many academics to question the validity of market efficiency and the CAPM. A recent example of this is Dempsey (2013). We pick up on two central tenets of Dempsey's paper—market efficiency and the status of the CAPM—and provide a critique. With respect to market efficiency, we argue that it is still very difficult to make abnormal returns from publicly available information and thus the basic tenet of market efficiency still holds. With respect to asset pricing models, we argue that the CAPM is still the reigning champion of asset pricing models and the belief that unless a model works 100% of the time that it should be rejected for an unspecified alternative is misplaced. In the spirit of a lively discussion we argue that the CAPM is half-right and everything else is wrong.

1 MARKET EFFICIENCY

Dempsey (2013) makes the following claims: He quotes Mehrling (2007) in saying that 'the first major step in the development of modern finance theory' was the efficient markets hypothesis (p. 7) and argues that the 'the paradigm of the CAPM and efficient markets may need to be replaced with the paradigm of markets as vulnerable to capricious behaviour' (p. 9).

We argue that the efficient markets hypothesis is historically important but is not one of the core ideas of finance and it is not the idea on which the CAPM is based. The core ideas of finance are threefold:

1. The time value of money: Historically, finance and valuation are rooted in the idea of the time value of money. The idea is centred on the work of Fisher (1930) in *The Theory of Interest*. The idea is simple—a dollar today is worth more than a dollar tomorrow. This idea is the basis of all valuation.
2. Diversification: This central idea is based on the Nobel Prize winning work of Markowitz (1952) and Sharpe (1964). The idea here is straightforward. If investors want to make as much money as they can with the least risk, they should diversify. Why? Because diversification reduces risk. The intuition here is that with a large portfolio holding, some assets will do very well, some will do very badly and most will perform up to expectations. Those that do very well will

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cancel out those that do very badly and fluctuations for the portfolio as a whole will be smooth and show little variation. If everyone is diversified this tells us something about how assets are priced—it gives us the required return for risk. This required return for risk is known as the CAPM. This concept is developed further in section 2.

3. Arbitrage: Modern finance began with the Nobel prize winning work of Modigliani and Miller (1958). The simple idea here is that if there are two ways to get the same cash flow they must have the same price. This idea is also known as valuation by arbitrage, 'law of one price' or 'no free lunch'.

So the efficient markets hypothesis is not a core idea of finance and not central to the development of the CAPM. Nevertheless, it is an important historical idea and one that claims as its core that it is very difficult to make abnormal returns from publicly available information. It has to be said that, even in these turbulent times in the wake of the GFC, this basic idea still holds as true as ever and no one is claiming that it has got any easier to make abnormal returns out in the marketplace. In fact, the asset management industry is marked by increased competition making outperformance (alpha) a rare commodity. On average and after accounting for costs, a passive portfolio is able to perform equally as well as a portfolio selected by investment professionals (Malkiel, 2005). This is the case over short horizons of one year where only 27% of U.S. mutual funds outperform the index and over longer horizons of 20 years where only 10% outperform.

2 CAPM

The second core idea of finance which we discussed in section 1—Diversification—is the basis of the CAPM. The idea is simple. Investors diversify because it reduces risk. This is a very powerful idea and the fund management industry is testament to this. The global funds management industry currently manages assets in excess of 80 trillion dollars[1] This industry captures the lion's share of the total value of conventional assets under management (including direct investments) of 120 trillion dollars.[2]

Clearly, the idea of diversification is considered of fundamental importance by financial markets. If everyone holds well-diversified portfolios (efficient portfolios), the sum of these efficient portfolios gives us the market portfolio which will be an efficient one since the sum of efficient portfolios is itself an efficient one.

Markowitz's (1952) mean variance frontier mathematics gives us

$$E(R_i) = E(R_{zp}) + \beta_{ip}E(R_p - R_{zp}) \quad \forall i \tag{1}$$

where $E(R_i)$ is the expected return on portfolio i, R_p is any efficient portfolio, R_{zp} is its zero covariance frontier counterpart and β_{ip} is the beta coefficient for portfolio i.

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[1] Measured in 2009 as conventional assets under management of the global fund management industry by Maslakovic (2011).

[2] Measured in 2011 as total assets under management across all housefuls including cash deposits, money market funds, listed securities and on/off shore assets as reported by BCG (2011).

Note that this is not the CAPM. This is a mathematical tautology that states that expected returns on all assets are spanned by two frontier portfolios and that there are an infinite number of *ex post* efficient portfolios that will satisfy equation (1). In fact, this relation holds regardless of the underlying data or how they are distributed. The result that expected returns are spanned by any two frontier portfolios applies any time you have a set of means and variances. For example, average scores of students on a series of tests versus the variance of the test scores, average scores by basketball players versus the variance of the scores, and of course the one we are familiar with, average returns of stocks versus the variance of the returns.

We cannot stress this enough! This is the fundamental point on the importance of the CAPM. The only testable implication of the CAPM is that the market portfolio is efficient, that it is one of the infinite number of mean variance efficient portfolios R_p that satisfy equation (1). The market portfolio is important and special because it is the only portfolio which we can specify *ex ante* to be an efficient portfolio.

In the words of Roll (1977, p 130):

> in any sample of observations on individual returns . . . there will always be an infinite number of *ex post* mean variance efficient portfolios. For each one, the sample betas calculated between it and individual assets will be exactly linearly related to the individual sample mean returns . . . These results are implied in earlier literature but I do not believe that their full consequences have been adequately explored previously.

What does this mean for the Fama and French factors? The implication is clear: if researchers are allowed to look *ex post* there will be an infinite number of portfolios that they can find that satisfy equation (1). By concentrating on the size anomaly and the market to book anomaly, Fama and French have found a workable method of constructing *ex post* efficient portfolios.

To see this in another way we can examine the parable put forward by Ferson *et al*. (1999) in which an empirical anomaly, based on the position in the alphabet of the names of companies, is used to create a factor that is used in asset pricing. The use of anomalies such as in this parable gives a workable method of coming up with *ex post* efficient portfolios. However, this says nothing about asset pricing as there are an infinite number of *ex post* efficient portfolios that will satisfy the mathematical tautology of equation (1). In fact this method of constructing *ex post* efficient portfolios is in effect picking the low lying fruit. Armed with a vector of *ex post* average returns and a historical variance–covariance matrix, any competent analyst could derive the entire range of *ex post* efficient portfolios—one for every value of standard deviation of return. All of these portfolios (along with their zero covariance frontier counterpart) will satisfy equation (1) but that does not mean that they are priced factors.[3]

So we are left with the fact that the empirical content of the CAPM is to be judged by the only *ex ante* efficient frontier portfolio that we know of—the market portfolio. The use of *ex post* factors based on size or market to book or the position in the

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[3] The same can be said for factors based on market anomalies such as accruals, momentum and conservatism.

alphabet of the company name falls into the trap of the mathematical tautology given by equation (1) and does not either support or contradict the CAPM.

This leads us to the issue of the composition of the market portfolio. Is it sufficient to use the Australian All Ordinaries index as a proxy for the market? Is it sufficient to use the Standard & Poors 500 Index as a proxy for the market; or is something more like a global stock index needed? It is our view that if you are to test the CAPM then the market portfolio alone must be used and a stand has to be taken on what is the market portfolio. If the market portfolio should be a broad representation of the overall market then clearly a global market index should be used. It should be noted that the global index has had considerable success in tests of the CAPM. For example, Harvey (1991) was unable to reject the CAPM using the market returns of 17 developed countries and a global market index.[4]

3 EQUILIBRIUM AND WHY THE CAPM IS ONLY HALF-RIGHT

Dempsey (2013, p. 7) states that 'The foundational model of market rationality is the capital asset pricing model'

In fact the fundamental model of market rationality is the Arrow Debreu state pricing approach which states that the price of any asset is given by:

$$P_i = \sum \Phi_{ts} F_{ts} \tag{2}$$

where P_i is the price of asset i; Φ_{ts} is the Arrow (1964) and Debreu (1959) state price for time t, state s; and F_{ts} is the payoff of asset i in time t, state s.

Breeden and Litzenberger (1978) and Banz and Miller (1978) outline how to obtain state prices using options on the market portfolio

$$\Phi_{ts,M}(X) = C''(X) \tag{3}$$

where $\Phi_{ts,\,M}(X)$ is the state price at level x of the market and $C''(X)$ is the second derivative of a call on the market at that level.[5]

This leads us to the value of the market as

$$P_m = \sum \Phi_{ts,M} F_{ts,M} \tag{4}$$

where $F_{ts,\,M}$ is the payoff on the market in time t, state s and P_m is the current value of the market.

Using the set of state prices on the market $\Phi_{ts,\,M}$, we can now find the value of any asset. We simply find the expected value of asset i conditional on the level of the market, $E(F_i|F_m)$, and multiply by the market state prices to obtain

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[4] You can test the CAPM with a market proxy as Shanken (1987, p. 107) argues that 'it is possible to test the theory conditional on a prior belief about the proxy-true market correlation'.

[5] This derivative can be calculated numerically using traded options (as is the case in the calculation of VIX Index) or analytically using the Black–Scholes (1973) model. In practice, it makes little difference since the resulting indexes are nearly 100% correlated.

$$P_i = \sum \Phi_{ts,M} E(F_i|F_m) \tag{5}$$

There are many ways to project this expectation but the common way is the linear projection $E(F_i|F_m) = \alpha_i + \beta_i F_m$ which yields

$$P_i = \sum \Phi_{ts,M} (\alpha_i + \beta_i F_m) \tag{6}$$

Now equation (6) looks very familiar and it is—it closely resembles the CAPM in payoffs.[6]

So the CAPM is looking good and is derivable from the fundamental economic model of rationality given by Arrow (1964) and Debreu (1959). However, it is via this approach that we are able to see that the CAPM can only ever be half-right. This is because:

1. The state prices ($\Phi_{ts,M}(X) = C''(X)$) (equation (3)) depend on the volatility of the market, the level of the market, the risk free rate, and the usual determinants of option value. Therefore the state prices could change continuously yet the CAPM assumes constant coefficients.
2. The conditional value of asset i, $E(F_i|F_m)$ (equation 5) may not be linear in F_m. There are all sorts of non-linear ways of taking this conditional expectation (see, e.g., the excellent text of Hastie *et al.*, 2009) but the CAPM only implies a linear projection with constant intercept and slope coefficients.

4 CONCLUSION

We conclude by thanking Dempsey (2013) for his provocative article. It gives the academic community a chance to reconsider the efficient market hypothesis and to examine just where we are at with asset pricing. We argue that it is just as hard (if not harder) to make a dollar in the market post the global financial crisis and that the core tenet of the efficient market hypothesis—that it is hard to make abnormal returns from publicly available information—still holds up as well as ever.

We have made a strong case that in terms of asset pricing the CAPM is still the only game in town and that the so-called factor models fall foul of the tautology of the Markowitz mean variance mathematics. However, relating the CAPM to the fundamental economic models of Arrow (1964) and Debreu (1959) we readily concede that the CAPM can only ever be half-right. Does this mean that we should discard the CAPM in favour of an unspecified alternative? In the words of Dempsey (2013, p. 21) this would lead us to

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[6] To see this note that $\sum \Phi_{ts,M} \alpha_i$ is the pricing kernel times a constant, which results in the price of a risk free asset and $\sum \Phi_{ts,M} F_m$ is the pricing kernel times the payoff on the market which yields the price of market risk.

a market where stock prices generally respond positively to good news and negatively to bad news, with market sentiment and crowd psychology playing a role that is never easy to determine, but which at times appears to produce tipping points, sending the market to booms and busts.

Consistent with the views of Benson and Faff (2013) we argue that you do not discard the CAPM in favour of an unspecified alternative which in essence means trading something that is half-right for something that tells us nothing at all. To paraphrase the words of the Nobel Prize winning economist, George Stigler (1967), 'on the journey from ignorance to omniscience seldom can we afford the full trip'.

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