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Actuaries' Evaluation of the Utility of Financial Economics

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Abstract: We identify two distinct cultures that take the study of the capital markets as their common specialism, namely, that of market practitioners and that of academic financial economists. The cultures differ in all that defines a culture: their value system. Accordingly, each has a distinct body of knowledge that evolves by a different selection process. We ask: what is the market's valuation of financial economics? It is shown that actuarial science had evaluated all the significant advances in financial economics almost as soon as they were made – sometimes even before they were made by financial economists. It is claimed that actuaries' evaluation of financial economics, given their market consistent value system, can be identified with the market's valuation. The key insights of financial economics from 1900 are evaluated. We conclude that if models in financial economics are to be judged solely by the accuracy of the predicted outcomes then the models developed to date are not fit-for-purpose.

Keywords: financial economics, history of financial economics, history of actuarial science, actuary, asset pricing models, option pricing, mathematical finance, efficient market hypothesis, corporate finance, investment strategies for pension funds, mark-to-market**.**

Introduction

C. P. Snow drew attention to "two cultures", the sciences and the humanities, arguing that their lack of mutual understanding and respect was detrimental to human development (Snow (1959)). The unhelpful division certainly existed after his 1959 Rede lecture when literary intellectuals took exception to his characterisation of them as "natural Luddites", indifferent or inimical to scientists who "have the future in their bones" (Kimball (1994)).

Of considerably less significance, though more delineated, are the two distinct cultures that take the study of the capital markets as their common specialism. Both groups submit to peer-review within their culture, but the cultures have different motivations and seek different rewards. In fact, the cultures differ in all that defines a culture: their value system. Accordingly, each has a distinct body of knowledge that evolves by a different selection process.

The two cultures associated with the capital markets are that of market practitioners and that of academic financial economists. The former submit to the 'mark-to-market' discipline while the latter submit to 'peer review'. The history of financial economics has been written largely from the academic perspective (see, for example, Bernstein (1992) and Dimson and Mussavian (1998, 1999, 2000)). In the academic version, market practitioners are often cast as the natural luddites, opposing advancement with ignorance by, for instance, persisting in stock-picking despite the dictates of the efficient market hypothesis, inefficiently employing capital to back guarantees on equity investments rather than adopting dynamic hedging strategies, deliberating over dividend policy when that is shown not to matter, continuing the cult of the equity in pension fund investing when bonds are shown to be preferable.

The standard version of the history of financial economics does not bother practitioners much: academic approbation is not what they seek. Market practitioners seek to be useful, and measure their utility by the financial rewards the market bestows on them. The market practitioner grouping includes all who submit to the judgement of the market – not just fund managers determined to “outwit the other fellow” in the game of outperforming the market average but also persons engaged in such diverse pursuits as, say, creating new financial products, engineering financial institutions to last centuries, or giving financial advice. What counts as success, and therefore prestige, in this sphere is profitability, wages, and their rate of growth. The market, through some mechanism, is thus the final arbiter and provides the ultimate measure of their valued added. Put simply, market practitioners are those who mark themselves to market.

Academics attribute the market’s method of arriving at the value of anything with laudable characteristics, such as informational efficiency. However, academics do not submit their theories to the market for evaluation, but to each other through the peer-review system. We ask: what is the market’s valuation of financial economics? It is shown that actuarial science had evaluated all the significant advances in financial economics almost as soon as they were made – sometimes even before they were made by financial economists. It is claimed that actuaries’ evaluation of financial economics, given their market consistent value system, can be identified with the market’s valuation. The key insights of financial economics from 1900 are evaluated. We conclude that if models in financial economics are to be judged solely by the accuracy of the predicted outcomes then the models developed to date are not fit-for-purpose.

ACTUARIES: FINANCIAL ECONOMISTS IN THRALL TO THE MARKET

This chapter outlines the significance the actuarial community put on key developments in financial economics. Actuaries may be viewed as financial economists who did a Faustian deal with Queen Victoria in the mid-nineteenth century. In return for agreeing to submit to the market’s judgement, actuaries were given monopoly privileges (and therefore higher wages) for maintaining the public’s confidence in pension, life assurance and other institutions that, together, have been the dominant participants in the capital market. Tom Ross, in his Presidential address to the Faculty of Actuaries, defined the actuary’s domain:

> “Our stock in trade may be regarded as the identification, measurement, pricing and management of risks – particularly but not exclusively, long-term financial risks – in a rigorous mathematical way.”
>
> Ross (2003, Section 1.5)

In return for their monoply, actuaries agreed to be judged, not by peers and not by intentions, but by the marketplace and by outcomes. Failure is market failure. Accordingly, with the recent closure of the Equitable Life Assurance Society to new business (a UK life assurance company intimately linked with the early development of the profession since the company’s founding in 1762), there was a Government investigation, not just into the affairs of the Equitable (Penrose (2004)), but into the entire UK actuarial profession (Morris (2005)). One of the outcomes of that investigation is that UK actuaries will no longer regulate themselves. Actuaries in senior roles in the Equitable – despite neither successful criminal or civil proceedings so far against them – were reprimanded or expelled from the profession. Failure of a theory in financial economics – or of a firm run by financial economists, no matter how short-term - does not excite such a reaction.

The actuarial profession embraced the values of practical application and utility from the outset. John Finlaison was one of those early financial economists who made the pact. From 1822 to 1851 he was the ‘Actuary of the National Debt’ and the ‘government calculator’ and became the first President of the Institute of Actuaries of Great Britain and Ireland in 1848. He articulated the values of the new profession:

> “The philosopher, stored with book knowledge and familiar with all the discoveries of previous and contemporary sages, is unable to work out a single idea, or to produce the most trifling invention; while the self-taught mechanic, by the strength of his own untutored genius, and unacquainted with any of those facts which the pioneers in science had made plain for their successors, produces, nevertheless, inventions and combinations, replete with harmony and beauty, which carry us far onward towards the practical application, to purposes of general utility..."

John Finlaison (1843)

The focus on utility as the value of all things is not opposed to academic rigour. Indeed, actuarial science has always maintained the trappings of academia – journals, textbooks, tutors, and examinations. As Poitras (2006b) observed "from the beginning of the subject in the eighteenth century, the techniques in actuarial science have been both mathematically rigorous and supported by careful empirical studies" (p. 70) but that "…the important intellectual and historical connection to actuarial science has been ignored" (p. 74) by financial economists.

Actuarial science has, however, not ignored the development of financial economics. In fact, actuarial science had evaluated all the significant advances in financial economics almost as soon as they were made – sometimes even before they were made by financial economists. However, the actuaries' value system, aligned with that of the market, had come to quite a different evaluation than that given in conventional histories of financial economics. We set out actuaries' evaluation of the key insights of financial economics. It is claimed that the actuaries' evaluation, given their market consistent value system, can be identified with the market's valuation of financial economics.

THREE DIVISIONS OF FINANCIAL ECONOMICS

The capital markets were invented before financial economics was recognised as an academic discipline. Poitras (2000) argues that the origin of financial economics "is part of the intellectual rebellion against the humanist dominance of universities, at the expense of studies aimed at practical applications" (p. 484) and identifies the key originator of ideas: "the most important contributor to the early history of financial economics: *Anonymous*" (p. 490).

Markets evolved by trial-and-error. The State, for instance, withdrew from its earlier attempts to raise capital by directly issuing life annuities or tontines, to issue fixed interest stock of different durations, which could be then used by financial intermediaries to create, and better manage, such derived instruments. The limited liability structure for companies overcame early setbacks, notably the

South Sea Bubble, which led to restrictions on the formation of limited companies after the Bubble Act of 1720 (Kindleberger (1993)). From the 1720s up to the early part of the nineteenth century in the US and middle of the century in the UK, political patronage was required to introduce special legislation for each and every venture with limited liability. Adam Smith (1776, Book V, Chapter 1) had argued that limited liability, as a business structure, was only appropriate to finance monopolies or other low risk activities:

> "The only trades which it seems possible for a joint stock company to carry on successfully without an exclusive privilege are those of which all the operations are capable of being reduced to what is called a routine, or to such a uniformity of method as admits of little or no variation. Of this kind is, first, the banking trade; secondly, the trade of insurance from fire, and from sea risk and capture in time of war; thirdly, the trade of making and maintaining a navigable cut or canal; and, fourthly, the similar trade of bringing water for the supply of a great city."

However, as the nineteenth century worn on, opinion changed and limited liability was urged for innovative enterprises (and monopolistic or staid activities often managed by the State). Key legislative reforms in the rapidly industrialising UK were the Companies Act 1844 and the Joint Stock Companies Act of 1856. By 1900, the limited liability company was the preferred structure for business ventures, and the debt and equity markets were largely of the form we know today.

Financial economics as a separate discipline is conventionally dated from 29th March, 1900. On that day, Louis Bachelier defended one of his theses, *Théorie de la Spéculation*, to the Academy of Paris for his *Docteur en Sciences Mathématique*. Since 1900, the discipline has developed into three distinct, but partially overlapping branches: mathematical finance, asset pricing models, and corporate finance (Dimson and Mussavian (1998, 1999)).

First, we have the original branch pioneered by Bachelier, the mathematical modelling of financial markets. The aim of this branch is to model the evolution of prices and thereby evaluate any function of these prices, such as guarantees and options. This branch relies on the mathematics of stochastic processes, especially diffusion and Lévy processes, to model the evolution of market prices over time. To make Bachelier's insightful work rigorous and extend its scope relied on developments made largely by probablists such as, Wiener, Lévy, Kolmogorov, Cramér (the actuary), Khintchine, and Itô. The Black-Merton-Scholes solution for the price of an option, assuming the price evolution can be modelled as a geometric Brownian process, was based on a result of Itô. The Black-Merton-Scholes formula was the watershed in financial economics, not solely because of its counter-intuitive result, but also because the techniques employed opened the floodgates in financial modelling and in financial engineering. Before 1973, financial economics was a subset of applied economics; after 1973, financial economics was important enough, and demanding specialist knowledge, to be considered a separate discipline.

Asset pricing models are concerned with the factors that drive security prices. It includes the dividend discount model, the expectation hypothesis of the term structure of interest rates, the Capital Asset Pricing Model (CAPM), the generic Arbitrage Pricing Model (APT), the Consumption-Capital Asset Pricing Model (C-CAPM), and the Inter-Temporal Capital Asset Pricing Model (I-CAPM). Again, there is little debate that the key developments in asset pricing came in the 1950s and early 1960s, beginning with Markowitz's initial problem in optimal portfolio construction, through the development of CAPM, until Sharpe's interpretation of CAPM as an equilibrium model. Within this decade many of the fundamental ideas were explored – investment risk, risk that can be expected to be rewarded, the relationship of the price of one asset to the price of all the others.

The third division of financial economics goes under the title 'corporate finance', and concerns itself with the optimum financial management of companies, treating such diverse concerns as the ideal capital structure, the best dividend policy, managerial remuneration and incentives, pension fund investment of employer-sponsored defined benefit schemes. The approach pioneered in Modigliani and Miller (1958) is, at the current time, the greatest insight as it enabled so many more insights.

Each of the above developments could be expected to have a dramatic impact on how actuaries go about their business. The press release announcing that Merton and Scholes were awarded the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel in 1997 put it pointedly:

> "The method adopted by this year's laureates can therefore be used to value guarantees and insurance contracts. One can thus view insurance companies and the option market as competitors."

However, actuaries did not find the Black-Scholes-Merton result, or any of the other key insights of financial economics, helpful in practice. The perspective the academic actuary Karl Borch adopted on mean-variance analysis that "...I shall continue to use mean-variance analysis in teaching, but I shall warn students that such analysis must not be taken seriously and applied in practice" was adopted by the whole profession on every one of the key insights. In short, the market was dismissive of the immediate applicability of the financial economics.

We treat how actuaries greeted each of the highlights in financial economics in each of the three branches.

MATHEMATICAL FINANCE

Bachelier's thesis is one of three remarkable thesis in the first few years of the twentieth century that modelled random processes through time (the others being the Lundberg's thesis in actuarial science of 1903 and Einstein's thesis of 1905 (see Cramer (1976), p. 513).

Bachelier took a unique approach to the markets:

> "The determination of these [asset price] fluctuations depends on an infinite number of factors; it is, therefore, impossible to aspire to mathematical prediction of it…. But it is possible to study mathematically the static state of the market at a given instant. If the market does not predict its fluctuations, it does assess them as being more or less likely, and this likelihood can be evaluated mathematically."
>
> Bachelier (1900a), translated by A.J. Boness in Cootner (1964), p.17.

So he studied price changes in the market through time. Bachelier was not going to second-guess which trader was on the right side of the deal, which gives the resultant stochastic process the useful property that 'the mathematical expectations of the buyer and the seller are zero" (Ibid., p. 27), that is, in modern terminology, the process is a martingale. The mathematics led Bachelier to develop an equation describing the price change process, an equation he recognised as the diffusion equation for heat. He showed that, in modern terminology, Brownian motion or the Wiener process is a solution. He considered some practical applications of the model, solving for the probability that a price will exceed (or, equivalently, fall below) a certain level within a given time period. The option prices he derives are not inconsistent with those traded on the market so he concludes:

> "It is evident that the present theory resolves the majority of problems in the study of speculation by the calculus of probability."
> (Ibid., p. 75)

It is erroneously maintained by some that Bachelier's work in modeling the evolution of asset prices was lost until rediscovered in the 1950s by Savage and Samuelson (see, for instance, Bernstein (1992) or Boyle and Boyle (2001)). However, its importance was recognised at the time the thesis was read – Poincaré gave the thesis an excellent report ("…one might fear that the author has exaggerated the applicability of Probability Theory as has often been done. Fortunately, this is not the case…" (as translated in Courtault, J.-M., Kabanov, Y. *et al* (2000))) and ensured it was published in the prestigious *Annales Scientific de l'École Normale Supérieure* (Bachelier (1900b)). Its methodology and results were widely disseminated and cited, although, as one can expect from the approach, the audience was largely mathematicians or probabilists (Cramér (1976)).

Given the importance of the topic and results to actuaries, Bachelier's work was quickly disseminated in a manner accessible to actuaries, including in a book, *Théorie et Pratique des Opérations Financières,* first published in 1908 by the French actuary Alfred Barriol, which went into several editions over the following decades. The second edition of Barriol's book was reviewed in the *Journal of the Institute of Actuaries* in 1914 where attention was drawn to the method of pricing options:

> "In connection with speculative Stock Exchange transactions, M. Barriol includes an investigation – based on the assumption that the distribution of prices would be in accordance with the normal law of error – of the theoretical relation of the *prime* to the *écart*, that is, as we understand it, of the price of a call-option to the difference between the call-quotation and the ordinary quotation for next settlement. ...but apart from doubts whether in such a case theory really exercises any influence over practice, and whether variations in prices could be regarded as following even approximately the law of error, it would seem to be difficult, in applying the formula practically, to determine the modulus of the particular curve to be employed for a specified security. At times of active speculation – when options are most in demand – the average deviation in the price of the security for the period covered by the option might be a very unreliable measure of the range of fluctuation."

Anonymous Book Review in
Journal of the Institute of Actuaries, XLVIII (1914), 311-312.

Actuarial requirements demand that the model must faithfully capture the phenomenon modeled. In the above instance, the model's failure to capture the observed heteroscedasticity (i.e., changing variance) of the price change series presented a crucial difficulty in "applying the formula practically". Later Working (1934) reported a similar finding that "a close student of stock-price behaviour" could differentiate between a random walk and a stock price series (p. 21) and, that "to the important extent that wheat prices resemble a random-difference series, they resemble most closely one that might be derived by cumulating random numbers drawn from a slightly skewed population of standard deviation varying rather systematically through time" (p. 24).

The main practical import from Bachelier's model of stock prices is the prediction that the standard deviation of the distribution of future price changes is directly proportional to the square root of elapsed time. Taqqu (2001) highlights that the French actuary Émile Dormoy in his *Théorie mathématique des jeux de hasard* had noted a similar empirical rule more than two decades earlier (Dormoy (1873) when he cites the work a decade before that again of Regnault (1863)). This paper, published in *Journal des Actuaries Français*, contains the following statement:

> "In order to get an idea of the real [option] premium on each transaction, one must estimate the mean deviation of prices in a given time interval...the mean deviation of prices is proportional to the square root of the number of days."
>
> Quote translated by Taqqu in Taqqu, M. (2001).

Apparently, this law was widely used on the French bourse and Bachelier may have learned it there when, prior to pursuing his doctorate, he worked in some capacity on the Paris Stock Exchange (Taqqu (2001)). Supporting this contention is that Bacheleir was clearly aware of the diagrammatic representation of option trading strategies, pioneered by Lefèvre, another French actuary. Granted, the empirical rule has no theoretical justification and refers to the mean deviation of prices (which is 20% lower the standard deviation in a Normal distribution). However, it was clear that French actuaries had a reasonable rule-of-thumb to price options before Bachelier's work.

Bachelier's work is rightly celebrated for establishing a promising approach to modelling the path of asset prices. However, he was not alone. Zimmermann and Hafner (2006) make the case that the forgotten academic actuary Vinzenz Bronzin in his 80-page booklet of 1908, *Theorie der Prämiengeschäfte*, anticipated every modern idea in option pricing - the put-call parity, no-arbitrage arguments, perfect-hedging pricing conditions, risk neutral pricing, and "his equation is closer to the Black-Scholes formula than anything published before Black, Scholes, and Merton. He moreover develops a simplified procedure to find analytical solutions for [European] option prices…" (p. 238). Bronzin's work had no effect on actuarial practice, for the same reasons as Bachelier's, viz., the model did not approximate the data generating process sufficiently closely to be reliably employed.

The next breakthrough in mathematical finance was in the spring and summer of 1973 with the publication of two separate papers, Merton (1973a) and Black and

Scholes (1973). The three authors had earlier pooled their ideas and as Fischer Black wrote:

> "A key part of the option paper I wrote with Myron Scholes was the arbitrage argument for deriving the formula. Bob [Robert Merton] gave us that argument. It should probably be called the Black-Merton-Scholes paper."
>
> Black (1988)

As many contracts issued by life assurance companies involve some level of guarantee on the ultimate benefits while investing in equities (e.g. with profits contracts issued by many UK offices), this insight could be expected to revolutionise the pricing and reserving of such contracts with their embedded put options. In fact, a stock market crash in the UK market in 1974 was focussing actuaries attentions on just these issues. Collins (1982), at the request of the *Institute of Actuaries*, produced a detailed assessment of whether the option pricing approach could be made to work reliably. Collins concluded that that such a hedging strategy "compares unfavourably with the conventional strategy" (of holding prudently high reserves) and that a "disturbing reason for the poor performance of the immunization [hedging] strategy was that from time to time (e.g. early in 1975) the unit price was subject to sudden large fluctuations which were inconsistent with the continuous model assumed in deriving it". Again, in short, the Black-Merton-Scholes approach relied upon the continuous sample paths of the underlying Brownian motion model but, in reality, asset prices had occasional jumps that made the replicating strategy unreliable.

Collins (1982) uses the word 'immunization strategy' rather than terms commonly employed by financial economists such as 'hedging' or 'self-replicating strategy'. The interesting reason behind this is that Collins (1982) was, in fact, assessing a proposal made in Fagan (1977). Fagan (1977) was presented to the *Society of Actuaries in Ireland*, which proposed, independently of Black-Merton-Scholes, a dynamic hedging of the reserves to meet investment guarantees, sketched a proof of the existence of such a strategy on the assumption that the trajectories traced by prices are continuous (i.e., are a diffusion process), and investigated, by simulation, whether a practical hedging strategy could be found to effect the safe release of reserves otherwise required. Interestingly, Fagan (1977) sees his ideas as a generalisation of the theory of immunization as developed by the celebrated actuary Redington (1952). [A brief overview of the history and development of the theory of immunization is given in Chapter 3 of Panjer *et al*. (1998).]

THE CAPITAL ASSET PRICING MODEL

Markowitz (1952, 1959) initiated a surprisingly fertile line of investigation into portfolio construction that was to shed light on investment risk and equilibrium prices in the market. Markowitz took return as the reward for investment and defined risk as the variance of returns. Each security is now modelled as a vector consisting of expected reward, expected risk, and the covariance of returns between the security and every other available security. Portfolio choice is reduced to an optimisation problem – to minimise the risk (variance of the portfolio) for a given level of reward or, alternatively, to maximise the reward for any given level of risk. Assuming that returns follow a Normal distribution (or applying a quadratic utility function of wealth), the portfolio construction problem is a quadratic programming problem that is, in theory if not in practice, soluble.

Markowitz's modelling never really engaged actuaries, as the insights it gave were well-known. Consider a liability portfolio a life assurance office, comprising lives insured for a specified amount and paying a premium per unit sum assured. Markowitz's phrasing of the investment problem is very similar to the optimum construction of such a portfolio of lives - maximising the surplus (premiums less claims), subject to a given variance (risk) - and carries essentially the same insights. Indeed, as the academic actuary Borch (1967) points out, the actuarial modelling of risk was altogether more sophisticated.

Markowitz's mean-variance framework, with the assumption of Normality of returns, gives a first-order model for understanding portfolio construction as it formulates the trade-off between risk and return and thereby, inter alia, quantifies the cost and benefit of diversification. Actuaries took two different lines in critiquing the model:

(1) In practice, the requirement to estimate the expected returns, the standard deviations and the correlations is so problematic and the resultant estimates so uncertain that Markowitz's approach produces portfolios no more

optimal than naïve ways of constructing a portfolio (see, for instance, Windcliff and Boyle (2004), for a recent development of this argument).

(2) In theory, using just the first two moments to define a preference ordering on distributions can lead to inconsistencies (see Borch (1974)). In particular mean-variance analysis can only be applied without restriction when asset returns are Normally distributed, which they are not, or assuming a quadratic utility function of wealth. These severe limitations allow Borch to conclude that "...I shall continue to use mean-variance analysis in teaching, but I shall warn students that such analysis must not be taken seriously and applied in practice" (p. 430).

However, Markowitz's simplification of the problem made it accessible to many more researchers. In particular, the framework was sufficiently rich to provide important theoretical insights in to investment risk. Tobin (1958) pointed out the unique role of the risk-free asset in Markowitz's model, and developed the Separation Theorem. The Separation Theorem states that the proportion of a portfolio held in the risk-free asset depends on risk aversion; the composition of the risky part of the portfolio is independent of the attitude to risk. That is, the construction of a portfolio is a two-stage process: first the level of risk is determined which gives the split between the riskless and the risky asset and, second, the portfolio of risky assets is selected, independent of the first step. The validity of this theorem can easily be seen by simple geometry in Markowitz's mean-variance space.

Further contributions from, in particular, Treynor, Sharpe, Lintner and Mossin, developed the mean-variance framework into the Capital Asset Pricing Model (CAPM). CAPM posits that the ex ante excess return (over the risk-free rate) expected from security *i* over the next time interval is related to the excess return over the risk-free rate on the market portfolio. i.e.,

$$E[R_i] - r = \beta_i (E[R_m] - r) \qquad \text{(FF.1)}$$

where

$$\beta_i = \frac{Cov(R_i, R_m)}{Var[R_m]} \qquad \text{(FF.2)}$$

and

R_i is a random variable denoting the ex ante return from security *i*.

r is the return from the riskless asset over same time interval.

R_m is a random variable denoting the ex ante return from holding the full universe of risky assets over the same time step.

Sharpe (1964) made a subtle but important contribution when he re-interpreted CAPM so that it was not simply a portfolio construction tool but a theory that could account for the relative prices of capital assets at a given time. Sharpe made clear the equilibrium relationships between risk and reward in markets, distinguishing between diversifiable risk, which is not rewarded, and undiversifiable risk whose reward above the risk-free rate is proportional to its beta. Some authors (for instance, Babbel *et al.* (2002)) contend that the actuary Karl Borch anticipated this development of CAPM in Borch (1962)).

The statement that the expected excess return from each security is a linear function of its covariance with the market portfolio is very strong, and, at first sight, can be easily tested empirically. Roll (1977) made the important point that CAPM is not, in fact, directly testable as any test is in reality a joint test of CAPM and that the market portfolio assumed in the test was really the market portfolio. However, Stambaugh (1982) reported that the results of empirical tests are not sensitive to the constitution of the market portfolio, even when the investment universe is widened to include bonds, property, and consumer durables. The CAPM model has been subjected to extensive tests over the years and the conclusion is that it does not adequately explain the cross-sectional variation in stock returns (see, for instance, Hawawini and Keim (2000) for a synthesis of the literature). In fact, valuation measures such as the price-to-earnings ratio or book-to-market value, commonly employed by fund managers, have been shown to have more predictive ability than a firm’s estimated beta.

The development of the theory of portfolio construction from mean-variance analysis to CAPM clarified elementary concepts such as investment risk, the distinction of what risks should command a reward, and an equilibrium theory of pricing risky assets. However, most of this was not new: actuaries, as the profession of risk managers, had their own more sophisticated theories on risk.

When asset pricing produced novel results, such as CAPM, then their explanatory power was less than well-known drivers of marker prices.

THE EFFICIENT MARKET HYPOTHESIS

Another theme in the development of financial economics that might have been expected to have a large impact on practice was the efficient market hypothesis. Fama (1970) gives an important synthesis and organisation of empirical research up to that time and concluded, "the evidence in support of efficient markets is extensive, and (somewhat uniquely in economics) contradictory evidence is sparse". Paul Samuelson spelt out what this implied for fund managers:

> "But a respect for evidence compels me to be inclined toward the hypothesis that most portfolio decision makers should go out of business – take up plumbing, teach Greek,... Even if this advice to drop dead is good advice, it obviously is not counsel that will be eagerly followed. Few people will commit suicide without a push."
>
> Samuelson (1974)

The efficient market hypothesis is, at heart, just Bachelier's assumption that the sequence of future price changes can be modelled as a martingale (with respect to a given information set). Bachelier simply stated it as a demarcation line between the specialism of market practitioners and financial economists – by pointing out that scientists investigating the price formation process may suppose a symmetry in the outcome of the exchange between the vast information processing of buyer and seller. However, now financial economists presumed to assess the information processing itself. Significant empirical studies in this regard were Cowles (1933) and Kendall (1953).

Cowles (1933) presents a statistical investigation into the abilities of professional forecasters to predict future market movements and insurance companies to add value by active portfolio management. He concluded that no professional adviser or investor had demonstrated skill but, that "there is some evidence, on the other hand, to indicate that the least successful records are worse than could reasonably be attributed to chance" (p. 324). Kendall (1953) studied the weekly UK Actuaries Index of Industrial Share Prices and its 18 sub-sectors over the period 1928-1938, together with the weekly price of wheat over a half century and the monthly price of cotton over a hundred year period. He concluded from his analysis that there were no patterns in the price series that can be profitably exploited or, as he put it:

> "Investors can, perhaps, make money on the Stock Exchange, but not, apparently, by watching price movements and coming in on what looks like a good thing."
>
> Kendall (1953), p. 18

However, the interpretation of the evidence in support of the efficient market was fundamentally flawed. The finding that statistical investigations could not find any exploitable opportunities or identify outperforming fund managers is probably saying more about the sophistication of the statistical investigations than about the markets or market practitioners. In fact, it would have been surprising if market practitioners, who are not above conducting statistical studies of their own, would have missed such obvious ways to enhance returns, especially as they would tend to act on *p*-values above those generally considered significant.

Dogmatic espousing of the EMH has declined in recent decades, and there is even a theoretical understanding that innovation can be rewarded in the financial sphere as elsewhere (Grossman and Stigler (1980)). The *Journal of Finance* now publishes articles purporting to demonstrate the existence of exploitable market opportunities (or 'anomalies' as they are often called). For instance, Lo, Mamayasky and Wang (2000) contest Kendall's conclusions in 1953 and with it the EMH in its weakest form when they claim that certain stock price patterns 'provide incremental information and may have some practical value'. Brown, Goetzmann and Kumar (1998) review some of Cowles' (1933) evidence with modern statistical methods and come to the opposite conclusion to his paper's title question *Can Stock Market Forecasters Forecast?* These recent papers add to the already voluminous literature on exploitable anomalies (e.g., the January effect, the 'Sell in May but buy back by St Leger's day' rule (Bouman and Jacobson (2002)) and other seasonalities in returns), but the evidence is difficult to assess due the problems associated with data-mining. Such studies are not about finding universal truths but, at best, about monitoring the influence the observer has on observed.

INVESTMENT STRATEGIES FOR PENSION FUNDS

According to the *Institutional Investors, Statistical Yearbook 2000* of the OECD, pension fund assets represent one-third of the assets managed by financial institutional funds across the world, with assets managed by insurance companies representing another one-quarter of the total. It is of interest to see how developments in financial economics influenced the management of these assets, and thereby affected the world capital markets.

Franco Modigliani and Merton Miller (MM) are credited with introducing the powerful technique of demonstrating a statement about the financial world is absurd if it leads to risk-free profits (i.e., arbitrage trades), as this could not hold in any equilibrium. Market practitioners, of course, did not have to be told this. MM applied the argument to demonstrate that, under idealised circumstances, the capital structure of the firm (in particular the debt to equity ratio) was irrelevant to how the market should value it. Modigliani and Miller (1958) marks the foundation of modern corporate finance. Modigliani and Miller (1961) extended the argument to show that investors should be indifferent to the company's dividend distribution policy. Sharpe (1976), Black (1980), Tepper (1981), adapted the MM argument to show that it implied that defined benefit pension schemes should be investing 100% in bonds.

Prior to the 1950s and therefore Modigliani and Miller (1958), pension funds invested proportionately little in equities, preferring debt securities. The British actuary Ross Goobey brought in the 'cult of the equity' by highlighting the case for equities in pension funds and, materially, led by example in switching the holdings of the Imperial Tobacco pension fund to equities in the 1950s (see Sutcliffe (2005)).

Table FF.1 sets out the evolution of the average asset allocation of pension funds from 1970 in those countries where the 'prudent man principle' underlies the trustees' investment policy. The table reinforces the point that when Sharpe (1976) and others were adapting the MM insight to pension fund investment, pension schemes were further increasing their exposure to equity investments.

Table FF.1: Evolution of Average Asset Allocation of Pension Funds where Guided by Prudent Man Principle, 1970-2001.

Asset Type	Year	Ireland	UK	US	Australia	Canada	Netherlands†
Equities	1970	n/a	49	45	15	27	11
	1980	37	52	41	15	26	5
	1990	53	63	46	27	33	20
	2001	65	71	59	63	58	50
Property	1970	n/a	10	0	2	1	16
	1980	19	18	0	13	2	14
	1990	11	9	0	16	3	11
	2001	9	6	2	9	6	6
Total Real Assets	1970	n/a	59	45	17	28	27
	1980	56	70	41	28	28	19
	1990	64	72	46	43	36	31
	2001	74	77	61	72	64	56
Gov. Bonds	1970	n/a	18	7	51	38	10
	1980	34	22	14	33	40	5
	1990	23	11	20	13	39	14
	2001	4	10	35	16	28	17
Other Bonds/Loans	1970	n/a	14	44	n/a	26	57
	1980	0	2	29	n/a	24	72
	1990	7	3	18	7	12	47
	2001	17	3	1	5	5	26
Cash	1970	n/a	4	1	n/a	5	3
	1980	10	5	8	n/a	9	2
	1990	6	7	9	23	11	3
	2001	2	3	2	5	2	2
Total Monetary Assets	1970	n/a	36	52	n/a	69	70
	1980	44	29	50	n/a	73	79
	1990	36	21	47	43	62	64
	2001	23	16	38	26	35	45
Other assets	1970	n/a	5*	3	n/a	3*	3*
	1980	0	1*	7*	n/a	-1*	2*
	1990	0	1*	7*	14*	2*	5*
	2001	3	7	2	2	1	
% of which foreign	1970	n/a	2	0	n/a	n/a	7

	1980	27	9	1	n/a	4	4
	1990	29	18	4	13	6	15
	2001	68	28	12	30	33	67

Sources: See Whelan (2003).

Exley, Mehta, and Smith (1997) engendered a long-running debate within the actuarial profession in the UK, the US and Canada when forcefully putting the case for a market-consistent method of valuing pension liabilities and investing the associated assets in bonds. Originally the debate centred on how to value pension liabilities and invest pension funds but has since grown to polarise the actuarial community into advocates of financial economics and advocates of the traditional actuarial approach. To simplify the debate to the point of caricature, the 'financial economist' group argue that pension funds should invest primarily in bonds, while the 'traditional actuaries' defend the common high equity exposure. A symposium, *The Great Controversy: Current Pension Actuarial Practice in Light of Financial Economics Symposium* gives an overview of the issues, with Gordon and Jarvis (2003) giving its history and Day (2003) giving a synopsis of the issues. The debate is on-going and, as yet, has not had a significant effect on the average asset distribution of pension funds. Two justifications can, I think, we made for the continued high equity exposure:

First, the MM argument does not lead inevitably to a 100% bond investment strategy. As remarked in Rubinstein (2003) "…it has become a commonplace to view the Modigliani-Miller Theorem not as a realistic proof that capital structure is 'irrelevant', but rather as a way of obtaining the list of reasons that make it relevant." In this regard, consider a firm sponsoring a defined benefit scheme. The company will have an expertise in manufacture or service delivery and desires a reasonable profit from employing that expertise. In a competitive industry, the company will strive to ensure that their competitive advantage in their chosen specialisation is not obscured by other, less controllable effects on profits such as, say, higher labour costs due to poor relative performance of pension assets. The obvious way to ensure against any such unwelcome deviations in these non-competitive parts of the business is simply to mimic its rivals in these aspects – copy their remuneration structure, and if this includes a defined benefit plan, copy the investment strategy. So, in accordance with the Modigliani-Miller insight, the actual investment strategy common within the industry does not matter but – and this is the key – it does not follow that the investment strategy adopted by the individual firm does not matter. It clearly matters if the company has systematically different wage costs to its rivals, which could happen with a radically different asset mix. So, outside of the investment management industry, one should copy one's competitors' pension investment strategy and copy all the more faithfully the more financially significant the pension promise, the more labour intensive the industry and the greater the price sensitivity of demand of the firm's product. Even inside the investment management industry one should pay close attention to the investment strategy of competitors, as one does not want poor relative performance jeopardizing both jobs and pensions at the same time. Note that, though the end result is the same as that of Modigliani-Miller – that the actual investment strategy pursued by pension plans in the industry is irrelevant, the mechanism is fundamentally different. Under the above analysis it is the consumer that ultimately bears the investment risk not, as under Modigliani-Miller, the shareholder.

Second, as developed in Whelan (2007), the mismatch risk to immature pension liabilities from equities and bond up to 20-year maturities are of the same order of magnitude when assessed in a market-consistent manner. Accordingly, if equities are expected to outperform bonds, then investing in equities is an optimum strategy. However, with the extension of duration in bond markets in recent times and the innovation of stripping, suitably long bonds now provide the least risk investment strategy. Alongside the growing ability to manage investment risk, the capacity to bear risk has been eroded over the last couple of decades as the previously incomplete pension contract has been more unambiguously defined by regulations, and surplus has been significantly reduced. These developments can be expected to increase the bond content of funds or, given the associated expected increase in costs, reduce the number of defined benefit schemes.

SUMMARY

Financial economists and market practitioners differ in a most fundamental way: on the criteria that they apply to decide what is good and what is not good. If financial economists are to be judged solely by the accuracy of the predicted outcomes of their models – to be either lavishly rewarded or severely punished – then the models developed to date are not fit-for-purpose. Such is the market's valuation of financial economics to date.

Of course, financial economics is still a relatively young science. Recent developments have attempted more realistic models. In asset pricing, for instance, Merton (1973b) and Breeden (1979) have extended CAPM into an inter-temporal setting. However, even these developments are not general enough to capture the full economic setting of the problem; they model only the demand side for securities, they do not yet address the supply side of firms issuing securities, which clearly is significant to their equilibrium price. Mathematical finance has moved to explore option prices and other functions of security prices when the underlying process has sample paths that mimic discontinuities often observed. The discovery that the returns from asset portfolios form a non-stationary series (Loretan and Philips (1994)), not only rules out almost all models of returns proposed to date (e.g.. all ARCH-type models and many regime-switching models are stationary), but the non-stationarity characteristic poses many non-trivial challenges to the statistical investigation of the markets, already compromised by limited data and a large data-mining community. It is quite clear that the more important developments of financial economics are still to come.

This chapter focussed on the clash of value systems between market practitioners and financial economists. However, the different selection mechanism of models evolves the body of knowledge within the two different cultures at a different pace and, perhaps, in a different direction. What does the collision of the two epistemological systems mean for the long-term future of financial economics?

Exploring the concept of equilibrium has proved fertile in financial economics – leading to Bachelier's identification of the martingale property, equilibria in game theory, and Sharpe's interpretation of CAPM. What properties would be an equilibrium point between these two epistemological systems possess?

Arguably, the history of the markets and, more generally, the history of technological advance, support the view that the trial-and-error method of the market is a more efficient mechanism of discovery and creation than the academics' application of the scientific method. In an unbounded world, can the scientific method with its need to demonstrate its propositions beyond reasonable doubt ever catch up with, as Keynes put it, the market's "spontaneous optimism" and "animal spirits"? It is a long shot. Maybe, though, Adam Smith was right in suggesting that the limited liability structure is not best suited for fundamental innovation. Financial economists are willing to make the investment of time, generally at some opportunity cost, to identify better ways to price and manage investment risk. In return, others should tolerate the harmless exaggeration of the importance of our discoveries to date.

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