FINANCIAL CRISIS OF METAPHOR

By

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This paper presents an analysis of the mathematical models of the prevailing orthodoxy within the field of financial economics in light of the financial crisis. The financial crisis presents a challenge to the language of orthodox financial economics. From an Austrian perspective, this challenge to the language of orthodox financial economics is centred on a small number of pressure points stemming from the mathematical-quantitative nature of the prevailing orthodoxy, especially the distortion of or obstruction to the communication of pertinent 'knowledge' by the adoption of a formalism that pushes aside many of the most important aspects of the human action represented in financial markets. The result is a crystalline structure of mathematical models that suffers from serious salience imbalance. The highly salient features of mathematical objects are not directly applicable to and have a low salience in the list of features of the financial economic reality. The financial crisis has accentuated this salience imbalance. The orthodoxy has experienced a financial crisis of metaphor.

Keywords: Orthodox, financial economics, language, Austrian, formalism, salience imbalance, financial crisis

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The financial markets are a manifestation of human action. The Austrian praxeological approach to developing an understanding of this human action stands in direct contradistinction to the prevailing orthodoxy within modern financial economics. It is an appropriate time to consider, from an Austrian perspective, exactly where the challenges to the prevailing orthodoxy strike with most force. This is a prelude to the positioning of Austrian theory of financial markets and the trade cycle at the forefront of competing explanations and an essential step in establishing which human actions are overlooked by the prevailing orthodoxy of modern financial economics. At the heart of all of this is the *language* that is used to develop economists' understanding of the relevant human action. This paper identifies the challenge that the financial crisis presents to the language of the theoretical structure of orthodox financial economics—a challenge to the metaphors and the salience attributed to particular elements of the economic reality—and highlights the elements of human action that may be better understood by an application of the Austrian economic theory.

II. THE PREVAILING ORTHODOXY: WHERE THE CHALLENGE STRIKES

The financial crisis challenges the *language* of the prevailing orthodoxy: it challenges what can and cannot be spoken or written about utilising the language of the prevailing orthodoxy and it challenges the meaningfulness of its discourse. And since this language—or at least its most important parts—is metaphorical, the facts and experiences represent a challenge to the metaphors that constitute the theoretical structure of the prevailing orthodoxy. By way of clearing the ground, it may be well to establish, first, what is meant by 'metaphor' in a general sense or from the point of view of literary theory; and secondly, the function and significance of metaphor in science and the mirroring of this function and significance in the particular theoretical and scientific discipline called financial economics. Orthodox financial economics is a crystalline structure of mathematical-metaphorical mappings between elements of the economic reality and mathematical objects. As such, the discourse of financial economics orthodoxy is confined to its crystalline structure and new facts and experiences may not be spoken or written about meaningfully without some, perhaps substantial, change to the structure of the orthodox position. Or the new facts and experiences may highlight longstanding deficiencies within the crystalline theoretical-mathematical structure that render it invalid. Once the difficulties presented by these theoretical deficiencies become insurmountable there may take place a reordering of competing explanations.

III. BACKGROUND

The order of competing explanations within a category of knowledge depends upon the relative dominance of the discipline's (metaphorical) models. For example, the competing explanations within the category of knowledge called quantum mechanics were dominated, in the early part of the 20th Century, by the Bohr Model, a powerfully vivid model that depicted the atom as a miniature solar system. Subsequent theoretical and experimental developments within quantum mechanics produced competing mathematical-geometrical-metaphorical models that captured more of the elements of the physical reality. The history of 20th Century physics is characterised by the development of mathematical-metaphorical models that emerge and, if they do not fade away immediately, may eventually displace existing metaphors in the continuous reordering of explanations that occurs with both purely metaphorical developments—new models or extensions of existing models—and practical, empirical, experiential or experimental developments that generate the conditions necessary for a reordering of the competing metaphorical models.

The process that a discipline undergoes when its metaphorical models are reordered cannot be understood thoroughly without an understanding of the prominent features of metaphor scholarship. This can seem to be a formidable task because the scope and magnitude of the literature generated by metaphor scholarship is surprisingly large. The theory of metaphor is rich and diverse and a burgeoning literature has emerged that encompasses contributions from literary theorists, philosophers, cognitive psychologists and neuroscientists among many others. For the most part, it is now accepted that metaphors (somehow) create analogies between a topic and a vehicle. This is the essence of Black's (1955, 1962, 1979) interaction theory of metaphor. When we say, "Richard is a lion," the topic (Richard) and the vehicle (lion) interact. The interaction takes the following form: the topic causes the selection of certain features of the vehicle—brave, ferocious, dominant—which are then used in comparison with the topic (Thomas and Mareschal 2001). Our understanding of Richard is altered. An analogy is created by the metaphor between Richard and the lion. Richard comes to be understood in terms of the lion.

The importance of metaphor in both language and scientific discourse derives from the creation of analogy between topic and vehicle. For appropriate listeners and readers, the creation of analogy between topic and vehicle is understood—meaning is conveyed—and, furthermore, where the topic is something about which little is known or understood, the metaphor, by creating an analogy between the topic and a vehicle whose properties are less clouded, contributes to a growth of knowledge about the topic. In scientific discourse where the metaphors are mathematical models, the mathematical-metaphorical models create analogies between topic (some element of reality) and vehicle (mathematical objects). The mathematics is well understood—a feature that derives from the understanding of the rules that govern the utilisation and interaction of particular mathematical objects. By creating an analogy between some element of reality and some mathematical object, the analogy casts the topic that is not well understood in terms of a mathematical model that is, from the point of view of the operation of the model on a purely mathematical level, well understood.

The creation of analogy between topic and vehicle may cast the not-well-understood in terms of the understood but there is another aspect that is just as significant. The creation of analogy between a topic and vehicle provides an opportunity for the creation of 'metaphor within metaphor'. These two characteristics of metaphor are powerful driving forces underlying the establishment and eventual reordering of explanations within a category of knowledge. The opportunity for creation of metaphor within metaphor, however, is a powerful force in propelling an explanation to the forefront of a category of knowledge and maintaining its hold on that position. The opportunity for metaphor within metaphor provides the opportunity for extension and growth of a particular explanation that permits it to encompass more elements of the underlying reality it seeks to explain. Where this opportunity is lacking, explanations quickly run up against a wall and are overrun by competing explanations with a greater growth potential. When the opportunity becomes exhausted, further growth of a particular explanation within a category of knowledge comes to a standstill.

Within the category of knowledge collected under the heading of financial economics, the tools and theories of metaphor scholarship may be utilised to explore the nature of the mathematical-metaphorical models that have emerged to form a prevailing orthodoxy that purports to explain particular elements of the financial economic reality. These models have been considered to be meaningful contributions to the discourse of financial economics—the mathematical metaphors have been understood and, in the process, elements of the financial economic reality have come to be viewed in terms of the mathematical objects that constitute the mathematical theory of financial economics. Suppose, for example, there are J different assets and S states of the world. Let r_S^J be the state-contingent cash flows which each asset J delivers in state S. Then, the financial market is a return matrix:

$$
\begin{array}{c c}
 & \begin{array}{ccccc} 1 & . & . & . & J \end{array} \\
\begin{array}{c} 1 \\ . \\ . \\ . \\ S \end{array} & \begin{bmatrix} r_1^1 & . & . & . & r_1^J \\ . & . & & & . \\ . & & . & & . \\ . & & & . & . \\ r_S^1 & . & . & . & r_S^J \end{bmatrix} =: r.
\end{array}
$$

Here, the topic (financial market) causes the selection of certain features of the vehicle—elements of matrix algebra—which are then used in comparison with the topic. The reader's understanding of the financial market is altered. The mathematical financial economic theory—the mathematical-metaphorical model—creates an analogy between the financial market and the return matrix. The financial market comes to be understood in terms of the return matrix. Whereas the topic may not have been well understood before, once it has been cast in terms of matrix algebra various features of the financial market come to be understood through their created analogical relationship with the relevant mathematical objects and operations.

The casting of the financial market in terms of matrix algebra generates the opportunity for the creation of metaphor within metaphor. Once created, the initial analogy between the financial market—an element of the financial economic reality—and the mathematical objects of matrix algebra enables the orthodox financial economic theorist to encompass additional elements of the financial economic reality within the mathematical-metaphorical model by constructing and communicating mathematical metaphors that create analogies between particular financial economic elements and particular objects and operations of matrix algebra. For example, a bond (a particular financial security and element of the financial economic reality) may be mathematically-metaphorically redescribed as a vector in the space defined above that delivers a constant unit amount in every state:

$$r^{\text{risk free bond}} := \begin{bmatrix} 1 & 1 & \ldots & 1 \end{bmatrix}'$$

Mathematical-metaphorical models must be comprehended and considered to be meaningful contributions to the relevant scientific discourse in order to attain any place among the order of competing explanations within a category of knowledge. The process of comprehension of mathematical-metaphorical models and why and how mathematical and literary metaphors have meaning is the subject of considerable scientific inquiry. Whilst the interaction theory of metaphor is the dominant theory of metaphor, the focus of much contemporary metaphor scholarship is on the nature of the interaction—what is happening cognitively during the comprehension process. There are a number of competing possibilities. These fall into two main groups (1) those which are based on comparison of topic and vehicle through some sort of categorisation or mapping of characteristics; and (2) those which are based on a mapping process between the topic *concept* and vehicle *concept*, rather than involving a comparison of the characteristics of the topic and vehicle. It is clear that, whichever theory may eventually prove to be the most adequate, the reader or listener must be aware of some set of characteristics or concepts—a set of associated commonplaces—in order to comprehend the metaphor.

The mathematical-metaphorical models of financial economic theory will not be understood as meaningful contributions to discourse by those who have no knowledge of either topic or vehicle or both. Such had been recognised relatively early by Black (1955). The reader or listener could not be completely ignorant of the features of the vehicle if the metaphor was to be understood. In Black's theory, the reader or listener must know what Black calls the system associated commonplaces. Consider the statement, 'Man is a Wolf.' Black explains: "A speaker who says 'wolf' is normally taken to be implying in some sense of that word that he is referring to something fierce, carnivorous, treacherous, and so on. The effect, then, of (metaphorically) calling a man a wolf is to evoke the wolf-system of related commonplaces. If the man [topic] is a wolf [vehicle], he preys upon other animals, is fierce, hungry, engaged in a constant struggle, a scavenger, and so on. Each of these implied assertions has now been made to fit the [topic] either in normal or abnormal senses…A suitable hearer will be led by the wolf-system of implications to construct a corresponding system of implications about the [topic]. But these implications will not be those comprised in the commonplaces normally implied by literal uses of 'man'."

In both scientific and literary discourse, no interaction between topic and vehicle can generate meaning unless the reader or listener is aware of the system of associated commonplaces. Providing the reader or listener is aware of the system of associated commonplaces—characteristics or concepts—a categorisation or mapping can take place. In the previous example, mathematical metaphor concerned a topic (financial market) and a vehicle (return matrix). The reader, upon reading the metaphor, will be led by the return matrix system of implications to construct a system of implications about the financial market. This construction, which is quite abstract in Black's work, is made more concrete by the modern view of interaction between topic and vehicle as a form of categorisation or mapping of characteristics or concepts. The categorisation or mapping of characteristics is a relatively straightforward model of metaphor comprehension where the interaction involves the listener placing the topic in the category denoted by the vehicle. The categorisation or mapping of concepts involves the listener experiencing the topic in terms of the source and it is not mere characteristics that are mapped but deeper aspects of experience (for example, emotions and perceptions).

To a reader who is aware of the relevant associated commonplaces of financial markets and matrix algebra, the interaction of topic and vehicle is likely to generate some meaningful contribution to discourse. The interaction of the financial market and return matrix that occurs during metaphor comprehension and generates this meaningful contribution to discourse may be explained according to some categorisation or mapping of characteristics model, as a placement of the financial market into the category denoted by the return matrix. The financial market falls into the category of things that the return matrix typifies—mathematical objects capable of particular operations. Alternatively, the interaction of the financial market and the return matrix that occurs during metaphor comprehension may be explained as the listener experiencing financial securities, the returns they generate and the various states of the world that may occur as elements of a mathematical object called a matrix. This may be described as a blending of the financial market with a pre-existing schema of a return matrix, itself a blend of various emotions and perceptions associated with the mathematical rules and operations of a particular piece of mathematics called matrix algebra (see Ritchie (2003, p.52)).

A metaphor invokes an interaction of the topic and vehicle. The nature of this interaction, according to the most recent metaphor scholarship, is some kind of categorisation or mapping of characteristics or concepts. In the context of mathematical finance or economics, the topic is some element of economic reality (consumers, producers, supply, demand etc) and the vehicle is some mathematical object (vector, matrix, cone etc). The metaphor, which may be stated as a theorem and accompanying proof, creates an analogy between the topic and vehicle and this analogy is understood or comprehended by an interaction—categorisation or mapping—between topic and vehicle domains. This view of metaphor is one in which the metaphor is more than a substitution of metaphorical for literal expression or the invoking of some simple comparison of topic and vehicle. Rather, metaphors have real cognitive content that alters our understanding of the topic. The topic comes to be understood in terms of the vehicle. The competing explanations of particular phenomena that are collected under various categories of knowledge are ordered and reordered as new metaphors are constructed or metaphor within metaphor is exploited. The process of metaphor (mathematical or non-mathematical) construction, communication and comprehension is central to the growth of knowledge. In this, the category of knowledge called financial economics is no exception.

IV. METAPHOR AND THE GROWTH OF THE FINANCIAL ECONOMICS ORTHODOXY

The apparently random fluctuations exhibited by stock markets and the prices of individual financial securities look very similar to those that characterise the movement of particles suspended in a liquid or gas. This similarity, once formally documented, has rarely been far from sight in most contributions to the theoretical structure of orthodox financial economics. Indeed, some of the results developed by Einstein and the mathematicians who formalised the mathematical foundations of stochastic processes were anticipated by a French mathematician's (Louis Bachelier) studies of the Paris stock exchange (Bachelier 1900). So the die was cast from the very beginning and orthodox financial economists would often draw on the rich variety of metaphorical models developed in the physical sciences and the associated mathematical formalisms that emerged alongside. This crystalline structure of interlocking financial-physical-mathematical models that characterises the prevailing orthodoxy propelled the growth of knowledge of financial economics during all of the 20th Century. The apparent certainty of the theoretical structure of orthodox financial economics seemed a comfort to those theorists and practitioners who would pit themselves against the relentless daily turmoil of the world's financial markets.

Before 1950 the operation of a portfolio had relied upon diversification among a 'reasonable number' of positions (see, for example, Graham and Dodd (1934)). The expected return for each position could be gauged by the difference between the estimated value of the financial security—estimated by a careful analysis of predominantly accounting information but still reliant upon the subjective judgment of the analyst—and the current market price. The risk involved in each transaction was gauged subjectively by the perceived likelihood that the financial security would not converge upon its estimated value and could, possibly, drift lower. Of course, the expected returns and risk of a financial security or portfolio are elements of the economic reality that exist as subjective judgments of market participants. Important steps were taken towards the (metaphorical) placement of these economic elements on a more objective and measureable footing. These can be attributed to Markowitz' (1952) work on the subject of portfolio selection in which—in three important pages of this paper (79–81)—he constructed metaphors between the economic elements of expected return and risk and mathematical objects that transformed the portfolio selection into a mathematical exercise amenable to further mathematisation.

Not surprisingly, mathematical statistics featured prominently in Markowitz' mathematical-metaphorical model of portfolio selection. The mathematical metaphor for a financial security is, according to Markowitz (1952, p.79) a random variable, *Y*, that can take on values $y_1, y_2, ..., y_N$. The probability that $Y = y_1; y_2; y_N$ is $p_1; p_2; p_N$. The expected value of an individual financial security (random variable) is then not a subjective element but one that is metaphorically objective:

$$E = p_1 y_1 + p_2 y_2 + ... + p_N y_N$$

And the risk of an individual financial security (random variable) is (metaphorically) the variance of *Y* defined as:

$$V = p_1 (y_1 - E)^2 + p_2 (y_2 - E)^2 + ... + p_N (y_N - E)^2$$

Of course, a portfolio is a combination of random variables and Markowitz' purpose is to provide a theory of portfolio selection. To do this requires the utilisation of a few more concepts from mathematical statistics. The expected value of a portfolio of financial securities (a combination of random variables, R_i) is simply the weighted average of the expected values of each of the random variables that constitutes the portfolio:

$$E(R) = \alpha_1 E(R_1) + \alpha_2 E(R_2) + \ldots + \alpha_n E(R_n)$$

The variance of a combination of random variables is not simply the weighted sum of the variance of the individual variables. Variances can dampen or reinforce each other and the covariances must therefore be taken into account. The covariance between two random variables R_i and R_j is defined as:

$$\sigma_{ij} = E\{[R_i - E(R_i)][R_j - E(R_j)]\}$$

And the variance of a weighted sum of random variables is:

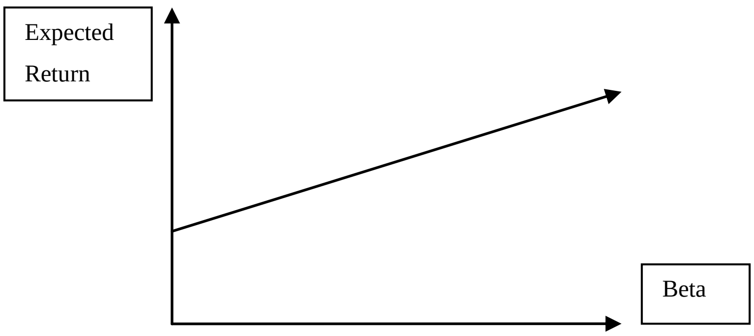
$$V(R) = \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j \sigma_{ij}$$

The portfolio selection problem of individual investors is then a choice of combinations of *E* and *V* given fixed probability beliefs concerning the expected value for each financial security and its covariance with other financial securities. Whilst still fundamentally subjective estimates, the metaphorical quantification of expected return and risk pushed this subjectivity further into the background. The historical returns and variances of financial securities became the key reference points for estimate of future (expected) returns and risk. Subsequently, the estimation process became more and more the product of sophisticated mathematical analysis and the utilisation of mathematical statistics further reinforced the metaphorical objectivity of expected returns and risks of financial securities.

The metaphors constructed by Markowitz created an analogy between elements of the economic reality that are subjective and individual and mathematical-statistical objects. The impact of this metaphor on financial economics was significant and primarily due to the (metaphorical) quantification and objectification of expected return and risk. By reducing investment analysis to a mathematical exercise, the construction of further mathematical metaphors on this foundation became possible. This is the foundation upon which the equilibrium models of Sharpe and Lintner were built. If all investors chose their portfolios according to Markowitz methods, assets would be priced (in equilibrium) according to the Capital Asset Pricing Model (CAPM). This mathematical-metaphorical model of the capital market is a combination of a number of mathematical-economic metaphors and the metaphors of Markowitz portfolio selection theory. Specifically, by metaphorically redescribing an investor's satisfaction as a utility function and specifying that the investor's utility is a function of (Markowitz) expected return and risk, the portfolio selection problem facing investors can be reduced to a utility maximisation problem where the investor attempts to maximise utility by choosing among combinations of *E* and *V*. Of course, more expected return contributes positively to utility whilst more risk contributes negatively.

Risk was once again redefined and within the context of the CAPM came to be the ratio of the portfolio's or financial security's covariance with the stock market's returns to the variance of the stock market's returns. This ratio is called beta. The standard deviation of a portfolio can be reduced through diversification by taking advantage of the covariances between financial securities. The expected returns of financial securities are not perfectly correlated and the variations tend to offset one another when they are combined a portfolio. Because of this, investors will only be rewarded for the risk that they cannot avoid through diversification. This is beta or systematic risk and is risk attributable to the portfolio's or financial security's relationship with the economic system. The relationship between the expected return and beta for a portfolio or financial security is a positive linear relationship in expected return–beta space. The two-dimensional geometry of the CAPM proved to be stunningly vivid:

Figure One: Capital Asset Pricing Model Geometry



The security market line (SML) intersects the vertical axis at the risk-free rate of return. It depicts geometrically the positive linear relationship between expected return and beta. In equilibrium, all financial securities and portfolios (points of *E* and *V*) fall on the SML. Financial securities and portfolios that lie off the SML will quickly gravitate towards the SML as investors take advantage of under-priced or over-priced financial securities and portfolios. The CAPM (and SML) was accepted as a meaningful contribution to the discourse of financial economics. For more than two decades, average returns and the risk of financial securities and portfolios—elements of the economic reality—were believed to be well explained by the CAPM: higher betas would be associated with higher average returns.

The expected returns characterisation of capital markets equilibrium also provided the 'empirical content' to perhaps the largest research programme in orthodox financial economics: the efficient markets hypothesis (Fama 1970). Support of the efficient markets hypothesis underpins the remaining two 'pillars' of the theoretical and empirical view of the financial system that had been established by the 1980s: (1) the unpredictability of returns; (2) the inability of professional managers to consistently outperform the market averages on a risk adjusted basis. By necessity, the expected returns characterisation of capital markets equilibrium lays at the foundation of these theoretical and empirical conclusions. Fama (1970, p.384) commented on the mathematical-metaphorical application of the mathematics of expected value to financial securities and portfolios:

> We should note right off that, simple as it is, the assumption that the conditions of market equilibrium can be stated in terms of expected returns elevates the purely mathematical concept of expected value to a status not necessarily implied by the general notion of market efficiency. The expected value is just one of many possible summary measures of a distribution of returns, and market efficiency per se (i.e., the general notion that prices "fully reflect" available information) does not imbue it with any special importance. Thus, the results of tests based on this assumption depend to some extent on its validity as well as on the efficiency of the market. But some such assumption is the unavoidable price one must pay to give the theory of efficient markets empirical content.

The growth of knowledge along orthodox lines proceeded on the basis of a combination of the expected returns characterisation of capital markets equilibrium—a metaphor that created an analogy between elements of the economic reality and objects of mathematical statistics—and the idea of 'efficiency'. Equilibrium expected returns are formed on the basis of a particular information set and 'fully reflect' the information contained in the information set[2]. This particular line of theoretical reasoning loops backwards to the starting point of the mathematical-metaphorical construction and, through the filter of the metaphor created, leads the financial economist to view market prices (an element of the economic reality) in a new and different way: as random variables whose successive changes are independent.

[2] We shall leave aside any detailed discussion of the metaphor that creates an analogy between the information available to market participants and the mathematical object of a set.

In all but the 'pure' areas of science, theoretical reasoning is examined against the relevant underlying reality by empirical investigation. The mathematical-metaphorical expected returns-efficiency structure of financial economic theory established between 1950 and 1970 was exhaustively subjected to empirical analysis. The 'state of the arts' with regards to tools of empirical analysis plays an important role. By comparison with contemporary techniques, many of the empirical investigations undertaken between 1950 and 1980 are elementary. Nevertheless, results were generated and many of the properties that were expected of the relevant economic elements (when viewed through the mathematical-metaphorical filters of the prevailing orthodoxy) were found to be somewhat reflected—or mimicked (Batemarco 1994)—in those economic elements. A view of the financial economic reality characterised by the CAPM, the un-predictability of returns (or, what amount to roughly the same thing, asset prices characterised by a random walk) and the inability of professionals to outperform the market averages was established (Cochrane 1999). However, the close ties between financial economics and the physical-mathematical sciences and the ever-present random walk or Brownian motion concept would make it only a matter of time before the evolution of asset prices through time would become the focus of orthodox financial economic theorists.

The first steps towards a continuous time formulation of financial economic theory were taken as soon as asset prices began to be viewed through the filter of the physical models of Brownian particle motion and the associated mathematical statistics. Just as some of the final steps were being taken towards the formation of the first complete orthodox view of the financial economic reality, Merton (1969; 1971; 1973a; 1973b) in a series of papers reformulated both the portfolio selection problem and the static CAPMs into a continuous time setting. Whilst Merton (1969 and 1973b) initiated the continuous time research program in modern financial economics, the publication of Merton (1973a) and Black and Scholes (1973) changed the way in which orthodox financial economic theorists viewed the financial economic reality. This was accomplished through the construction of a new and intuitively appealing and vivid mathematical-metaphorical filter through which to view financial securities and portfolios.

The options pricing models developed by Merton (1973a) and Black and Scholes (1973) cast off the static frameworks that preceded them and utilised the new continuous time formalism to generate new results that would not have been possible within a static theoretical structure. Call options are financial securities and elements of the financial economic reality. Within a mathematical-metaphorical structure characterised by continuous time, the options pricing models establish an equivalence between the payoffs associated with a call option and the payoffs associated with a portfolio consisting of the underlying stock and borrowing. Dynamic portfolio rebalancing in 'complete' markets can generate a 'synthetic' call option. Because the portfolio and the call option have the same payoffs, they must have the same price. This important contribution to financial economic theory is based on the mathematical-metaphorical representation of the dynamics of the financial economic reality and the mathematical-metaphorical structure of 'contingent claims' that, in addition to permitting the results generated by Merton (1973a) and Black and Scholes (1973), produced mathematical-metaphorical filter through which orthodox financial economists began to view other elements of the financial economic reality—stocks, bonds and other derivatives—as 'contingent claims'.

Contingent claims asset pricing would eventually provide the mathematical-metaphorical filter through which most assets would come to be viewed by financial economic theorists. In the meantime, the continuous time mathematics introduced by Merton (1969) and utilised so successfully in conjunction with contingent claims analysis to construct options pricing theory, would be put to considerable use in re-shaping the static CAPMs of Sharpe and Lintner. The original CAPMs set up a simple relationship between expected return and beta (risk) without incorporating any of the dynamics of the financial economic reality explicitly:

$$E(R_i) = r_f + \beta_i \left(E(R_M) - r_f \right)$$

Merton's (1973b) Intertemporal CAPM (I-CAPM), which is based on the assumption that trading on financial markets takes place continually in time (Merton 1973b, p. 869), is a statement of dynamic capital markets equilibrium that is a generalisation of the static CAPM (Merton 1973b, p.882):

$$\alpha_i - r = \frac{\sigma_i \left[\rho_{iM} - \rho_{in}\rho_{nM} \right]}{\sigma_M \left(1 - \rho_{nM}^2 \right)} (\alpha_M - r) + \frac{\sigma_i \left[\rho_{in} - \rho_{iM}\rho_{nM} \right]}{\sigma_n \left(1 - \rho_{Mn}^2 \right)} (\alpha_n - r) \qquad (i = 1, 2 \ldots, n-1)$$

The model, which geometrically is a security market plane rather than the security market line of the static CAPM, states that investors are compensated for bearing systematic risk and unfavourable shifts in the investment opportunity set with higher expected returns. Investors with long investment horizons, for example, will be unhappy when presented with news that future returns are likely to be lower (because his or her longer term wealth or consumption will be lower) (Cochrane 2001, p.172). Merton's (1973b) model captures the idea that expected returns depend on stocks' covariation with these changing investment opportunities as well as covariation with current market returns (the static CAPM conclusion).

Merton's (1973b) model is based upon a tightly specified mathematical-metaphorical structure that remains an underlying presence in subsequent asset pricing models. There were some simplifications, refinements and adaptations for special cases. For example: (1) Breeden (1979) showed that the multiple factors of Merton's (1973b) specification could be reduced to a single beta factor with respect to consumption; and (2) Ross (1976) took a statistical rather than economic approach to develop the multi-factor Arbitrage Pricing Theory. Like the CAPM and I-CAPM, these models all attempt to explain the behaviour of asset prices and expected returns through a mathematical-metaphorical model that ties the original E-V metaphors of mathematical statistics to a mathematical-metaphorical economic structure that creates analogies between elements of the financial economic reality and mathematical objects. The associated empirical investigations and theoretical adjustments that marked the growth of knowledge under the category of financial economics during the 1980s and 1990s eventually produced the contemporary orthodox view of the financial economic reality.

The contemporary orthodox view of the financial economic reality is one in which: (1) expected returns are described by multiple factors; (2) returns are predictable; and (3) professional managers can do better than the averages on a risk-adjusted basis (Cochrane 1999). The mathematical-metaphorical framework introduced during the 1970s remains the underlying foundation. Indeed, the particular way of viewing financial securities that emerged in Merton's (1973a) and Black and Scholes' (1973) options pricing models has become standard. Before the development of these models, assets such as stocks, bonds and derivatives were viewed as distinct elements of the financial economic reality and the mathematical-metaphorical models that attempted to describe and explain their behaviour theoretically maintained this distinction at least to some degree. Following the options pricing models, a new mathematical-metaphorical filter existed through which to view most financial securities as 'contingent claims': securities that pay one unit of a consumption good in one state of the world only tomorrow (Cochrane 1999, p. 51).

The geometry that is associated with a mathematical-metaphorical model performs the important role of facilitating visualisation, especially among the non-specialist theorists who adopt (or otherwise) a particular view of an underlying reality. Contemporary expressions of the contingent claims mathematical metaphor are accompanied by an appealing geometric structure that contributes significantly to the vividness of the metaphorical structure. Contingent claims formalism is popular because (in addition to its appealing and vivid structure) it is a filter through which most securities can be viewed. A completely general asset pricing equation is:

$$p = E(mx)$$

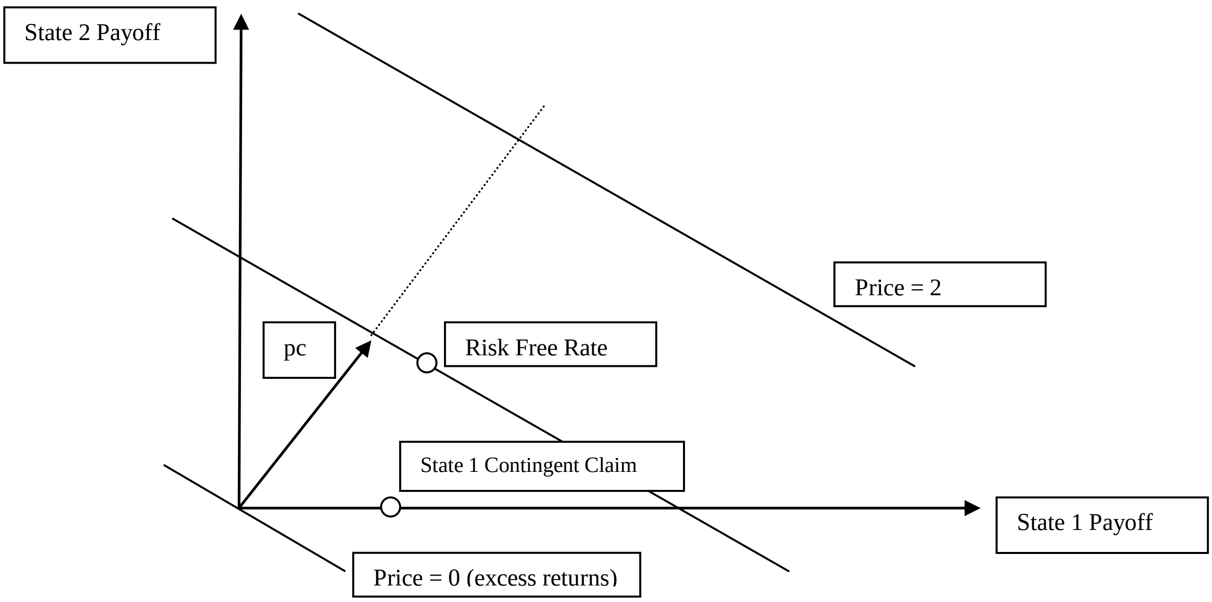
Where p is the price of the asset, E is the expectations operator, m is the stochastic discount factor and x is the payoff associated with the asset. This general asset pricing equation of which asset pricing models such as the CAPM and I-CAPM are special cases, can be interpreted as a bundling of contingent claims with the stochastic discount factor, *m*, defined as the contingent claims prices divided by probabilities (Cochrane 2001, p.51). In a two-period model (today and tomorrow) a contingent claim pays one dollar in one state *s* only tomorrow. The price of the contingent claim today that pays off in state *s* is $pc(s)$. Let $x(s)$ denote an asset's payoff in state *s*. The asset is a bundle of contingent claims—and one need not point out this metaphor within metaphor—to states—$x(1)$ contingent claims to state 1, $x(2)$ contingent claims to state 2 and so on (Cochrane 2001, p.52). The asset's price is (mathematically-metaphorically) the value of the contingent claims of which it is a bundle:

$$p(x) = \sum_s pc(s)x(s)$$

The contingent claims price pc and asset payoffs *x* are vectors in R^S. Each element gives the price or payoff in the corresponding state:

$$pc = [pc(1) \quad pc(2) \quad \ldots \quad pc(S)]'$$
$$x = [x(1) \quad x(2) \quad \ldots \quad x(S)]'$$

The appealing geometry associated with this mathematical-metaphorical redescription of an asset's price in terms of contingent claims is presented below (see Cochrane (2001)):



Of course, the mathematical operations of vector algebra can be brought to bear in the analysis of asset prices within the context of this mathematical-metaphorical model. This includes inner product representations for prices. Contingent claims formalism provides a very general framework for considering asset prices. The generality and the extensive opportunities for ‘metaphor within metaphor’ that accompany it place it at the forefront of the orthodox contribution to our understanding of financial economics. The growth of knowledge within financial economics has followed a path of metaphor construction, communication and comprehension. The dominant metaphors are the mathematical metaphors have been those of the prevailing orthodoxy. Through this filter the essential elements of financial economic reality are viewed as random variables that are elements of a real vector space. The development of this filtered orthodox view the financial economic reality is classified under the activity or phenomenon of ‘growth of knowledge’.

V. DISTORTION

Mathematical-metaphorical models are filters through which the financial economic reality is viewed. The mathematical-metaphorical models emphasise some features of the financial economic reality and relegate other features to the background. All metaphors and models must do this, of course, but the mathematical-metaphorical models are particularly pernicious when applied to human action. The features of human action that are less easily incorporated into the particular mathematical formalism are the most likely to be pushed aside. In arriving at the orthodox explanation of the financial economic reality, there have been many such compromises. Each step along the way might have seemed like a rather small one. For the most part this has indeed been the case. The biggest changes in economics have always been associated with the construction of completely new metaphorical models or explanations—new prevailing orthodoxies. The small steps involve the extension of those models or explanations through the expedient of the construction of metaphor within metaphor. But even small steps, when there are many, may lead us a long way from the original created analogy between topic and vehicle.

The contingent claims analysis that constitutes a key component of orthodox financial economic theory is a gradually accumulated series of consistent mathematical metaphors for elements of the financial economic reality. By casting these elements in terms of mathematical objects they have come to be understood in a certain way and, importantly, in order to accumulate a consistent series of mathematical metaphors that could be supported by mathematical theorem and proof, a large number of elements of the financial economic reality have been pushed to one side. Of course, to mathematically-metaphorically redescribe any reality, steps must be taken in order to create analogies that can be supported by theorem and proof. The mathematical-metaphorical structure that is the end product of these steps of abstraction and creation of metaphor within metaphor may be quite distant from the underlying reality and hardly recognisable, even analogically, to all but the most specialist readers or listeners. When the steps of abstraction and creation of metaphor within metaphor that have led to the contingent claims general equilibrium asset pricing theories of contemporary financial economic theory are traced the distance that has been placed between the prevailing orthodoxy and the underlying financial economic reality it seeks to explain is found to be significant.

The advent of a crisis increases the tension between the explanation of the prevailing orthodoxy and competing attempts to develop an understanding of the human action represented in financial economic reality. Even those who were content with the filtered view generated by the prevailing orthodoxy may begin to notice the elements of the financial economic reality that do not appear when one views it through the prevailing orthodoxy's mathematical-metaphorical filter. The tension escalates as the demand for concise articulation of the various positions ensues both on popular and purely scientific fronts. The elements of the human action represented in financial economic reality now so clearly visible to all—people, panic, power, mistakes, regulations, laws, scapegoats and media reports—are all so clearly absent from the prevailing orthodoxy's mathematical-metaphorical model. There is a tension between the filtered view of the prevailing orthodoxy and the filtered views of the competing explanations where at least some of these elements may be more recognisable within their theoretical structures. This tension that arises from the crisis also represents a crisis for the prevailing orthodoxy. It is a tension of metaphor. It is a crisis of metaphor.

VI. CRISIS, REVISION AND REORDERING

A crisis of metaphor is a breakdown of the interaction between topic and vehicle as characteristics of the topic that had been pushed into the background rise to the surface in light of the new facts and experiences. The construction of a mathematical metaphor creates an analogy between topic and vehicle. The elements of the financial economic reality (topic) are redescribed in terms of mathematical objects (vehicle). In many cases, these mathematical objects are elements of the matrix or linear algebra. For example, the list of financial securities that are traded on a particular market are redescribed as a vector in some vector space. The comprehension of the metaphor and its acceptance as a meaningful contribution to the discourse of financial economics involves an interaction between topic and vehicle which, according to contemporary metaphor scholarship, involves a mapping or categorisation of characteristics or concepts. In the same way that a literary metaphor—for example, "the man is a machine"—creates an analogy between a topic and vehicle, the mathematical-metaphorical model generates an interaction of financial economic elements and mathematical objects to create an analogy between those elements of the financial economic reality and the particular mathematical objects. The topic comes to be understood in terms of the vehicle.

Metaphor has long been understood to emphasise certain features of the topic whilst pushing other features into the background (see Black (1955)). This is the nature of the filter of which we have been speaking. The present discussion concerns what happens when facts and experiences bring those features that have been hitherto pushed aside to the forefront. When those ‘recovered’ features are the ones that dominate the category of the topic, the categorisation or mapping between topic and vehicle may breakdown to a lesser or greater degree and the vividness of the metaphor deteriorates. In all scientific work, facts and experiences may generate a revision of the prevailing orthodoxy. The category of knowledge called financial economics is no exception. Indeed, during a financial crisis, for reasons already discussed, the prevailing orthodoxy may be more prone, if not to outright revision, then at least to calls for such than the prevailing orthodoxies of those categories of knowledge that lie somewhat removed from public perception.

Financial economics is a peculiar case. It is not necessarily new facts and experiences that emerge, having previously been unknown, to initiate a revision of the metaphorical models constituting the prevailing orthodoxy but a rising to the surface of elements of human action represented in financial economic reality that had been pushed aside—though they were always known to exist. The prevailing orthodoxy within the category of knowledge known as financial economics has pushed aside a very large number of the features of human and emphasised those features which are amenable to the construction of mathematical metaphors. The creation of further metaphor within metaphor on this basis further distanced the models of the prevailing orthodoxy from the financial economic reality it once sought to explain. The financial crisis has highlighted the distance that has been placed between the mathematical-metaphorical models of financial economics and the financial economic reality. The interaction of individuals, firms, banking institutions and governments, each attempting to salvage their careers, positions, liquidity, solvency and credibility, may be observed on a daily basis and has no analogue within the structure of the prevailing orthodoxy of modern financial economics. Yet it is the financial crisis that highlights this and brings these elements to the foreground when once they were relegated to the background. This is a financial crisis of metaphor.

The foundations in literary theory for a crisis of metaphor of this nature lie in the salience matching theory developed by Tversky (1977) and expanded by Ortony (1979). This theory proposes that metaphoricity can be “represented in terms of the relative degrees of salience matching attributes of the two terms in a comparison” (Ortony 1979, p.161). A theory of similarity that may be utilised to explain similes, for example, may be constructed in a manner analogous to a geometric model in which the distance between two objects of comparison determines the similarity of the two objects. Ortony’s (1978) purpose was to augment extant theories of similarity to incorporate non-literal similarities or metaphoricity. Tversky’s (1977) theory had been well-supported by the data and appeared to account for the similarity that is adjudged to characterise two objects. In Tversky's (1977) theory, the degree of perceived similarity between A and B is a weighted function of the intersection of attributes of A and B minus the sum of a weighted function of the attributes distinctive to A and a weighted function of the attributes distinctive to B (Ortony 1979, p.163). In this model, the salience of an attribute depends on the particular object, A or B, of which it is an attribute and some other contextual factors (Ortony 1979, p.163). This theory will allocate equal weights to particular attributes regardless of whether they belong to A or B.

Ortony (1979) developed this theory by allowing that a particular attribute can be more important with respect to A than with respect to B. This is called 'salience imbalance.' One of his examples is as follows: being red is a more important attribute of a fire-truck than it is of a brick. The salience of an attribute is not independent of the object. Because, as Ortony (1979, p.162) argues, metaphoricity may emerge in part from the relative salience of matching attributes, 'salience imbalance' permits Ortony (1979) to better account for non-literal similarity or metaphoricity. When the matching attributes of A and B are of high salience for both A and B, the statement formed will be a literal statement. When there are matching attributes that have a lower salience in A than in B, whilst there are attributes of B that are of high salience to B yet not applicable to A, the statement comparing A and B will be metaphorical or non-literal statement. If there is a list of attributes for A and a list of attributes for B and if the lists begin with the most salient attributes for A and the most salient attributes for B, salience imbalance and, hence, metaphoricity, will be associated with a high degree of diagonality in any attempted mapping of attributes from B to A (Ortony 1979, p.164).

Ortony (1979, p.170) provides an example of salience imbalance and changing degrees of metaphoricity. This example involves a consideration of two statements, each containing some degree of metaphoricity:

(1) John's face was like a beet
(2) John's face was red like a beet

Ortony (1979, p.170) explains, "In Statement (2), John's face is compared to a beet with respect to redness. The effect of specifying the dimension is to identify, or "foreground", the most diagnostic attribute(s). Much the same would be true, although perhaps to a lesser extent, if *was like* in Statement (1) were changed to *looked like*. The consequence of foregrounding in Statement (2) is that all other attributes of both John's face and of beets have less impact on the perceived similarity between the two. Another way of putting this is to say that the salience of the colour attributes is increased above the salience of all the other attributes so that the latter no longer play a significant role. The result is a match of high-salient to high-salient attributes. Accordingly, judged metaphoricity should diminish from Statement (1) to Statement (2)."

The prevailing orthodoxy within the category of knowledge called financial economics has established a crystalline structure of mathematical metaphors that create analogies between mathematical objects and elements of the financial economic reality. The comprehension of these mathematical metaphors involves some form of categorisation or mapping of characteristics or concepts in a manner that is not inconsistent with the essence of the theoretical model of metaphoricity proposed by Ortony (1979). A statement from financial economic theory may be as follows: The asset economy is described by a matrix (u, ω, r), where *u* is the preferences of the agents in the economy, ω is the endowments of the agents in the economy and *r* is the available assets for trading. This metaphor for an asset economy embodies the metaphor that an agent or individual in this economy is defined as a vector (u, ω). The attributes of matrices and vectors—the properties that define their operations—have a lower salience in the topic (elements of the financial economic reality) than in the vehicle (elements of mathematics). The highly salient attributes for the mathematical objects are not applicable to the topic and the statements of orthodox financial economic theory are metaphorical.

The financial crisis of metaphor may be viewed as an extreme salience imbalance. Like Ortony's (1979) example of the metaphorical statement comparing John's face with a beet, the inclusion of 'redness' in the second statement tends to foreground that particular attribute and diminishes the salience of all other attributes of John's face and beets. In an analogous fashion, the facts and experiences that upset the prevailing orthodoxy, foreground particular attributes of topic and vehicle. A financial crisis foregrounds particular attributes of elements of human action represented in financial economic reality, including the fallibility of decision-making, the human characteristics of market participants, panic, power, mistakes, regulations, laws, scapegoats and media reports. The salience of the 'mathematical attributes' or those features of the elements of the financial economic reality that made it possible to comprehend the mathematical metaphors of the prevailing orthodoxy are decreased whilst, simultaneously, the salience of the attributes less amenable to precise scientific and, particularly, mathematical analysis is enhanced. This redefinition of the salience imbalance of attributes of the financial economic reality and mathematical objects threatens to render the existing mathematical metaphors of the prevailing orthodoxy anomalous or no longer possessed of the meaning once attributed to them.

The crisis of metaphor produces a severe salience imbalance and diagonality that renders the metaphors anomalous with a diminished clarity of meaning. Another way of picturing this crisis of metaphor is as disintegration to a lesser or greater degree of the categorisation or mapping that occurs as part of the interaction of topic and vehicle during the comprehension process. When facts and experiences alter the order that once prevailed within the structure of the associated commonplaces of topic and vehicle, the basis for any mapping or categorisation of characteristics or concepts becomes fractured. The mapping or categorisation of characteristics or concepts between elements of the financial economic reality and mathematical objects that constitutes the interaction of the topic and vehicle and, subsequently, the comprehension of the metaphor by the reader or listener cannot proceed as smoothly or efficiently nor generate a high degree of vividness when the salience imbalance between characteristics or concepts of topic and vehicle is such that the degree of metaphoricity becomes so great as to cloud the meaning of the metaphor itself or, perhaps equivalently, generates an anomalous outcome.

Once facts and experiences emerge, the system of associated commonplaces or the set of attributes of topic and vehicle or A and B are augmented, diminished or reordered. The salience imbalance is readjusted and the degree of metaphoricity may be diminished or increased. Diminished metaphoricity generates literalness and scientific models that become literal statements about elements of reality are rendered obsolete as models and become simply expressions of fact. Increasing metaphoricity may tend towards anomaly as the applicability to the topic of highly salient features of the vehicle becomes less clear. Within the category of knowledge called financial economics, mathematical-metaphorical models create analogies between elements of the financial economic reality and mathematical objects. Facts and experiences, particularly those that appear suddenly and with some degree of force, augments, diminishes or reorders the attributes of elements of the financial economic reality and mathematical objects. The metaphorical statement that an individual in the economy is defined as (u,ω) is a statement in which the attributes of the mathematical objects known as vectors have a low salience in the topic (an element of financial economic reality) and a high salience in the vehicle (mathematical objects). The metaphoricity that derives from this salience imbalance is also liable to be easily disturbed by a movement in this salience imbalance. The low salience of the attributes of the mathematical objects in the topic is overwhelmed by the foregrounding of different or new attributes subsequent to the emergence of new facts and experiences. The mathematical-metaphorical models of the prevailing orthodoxy increase in metaphoricity to the point of becoming anomalous and the mapping or categorisation of characteristics or concepts fractures. This is a crisis of metaphor.

VII. CONCLUDING REMARKS

Financial markets are a manifestation of human action[3]. The financial crisis of 2007 and 2008 is a fact or experience emerging from human action. The orthodoxy of financial economics is characterised by an attempt to develop quantitative models to explain and predict asset prices (see Batemarco (1994, p.216)). The orthodoxy is a crystalline structure of mathematical metaphors. The development of the orthodox position is punctuated by a gradual abstraction through metaphor within metaphor. This has pushed aside many of the features of the financial economic reality and with it much of the knowledge that economists possess about the human action represented by the financial markets. More than this, whatever knowledge is captured within the mathematical-metaphorical models of the orthodoxy and whatever elements[4] of the financial economic reality have been captured by the equations, is communicated in a manner that distorts or filters the elements of underlying human action and restricts comprehension of knowledge to a smaller group of individuals to whom the mathematical analogies are meaningful. Such is a distortion of the process of discovery (see Thomsen (1994, p.170)).

When the prevailing orthodoxy is a crystalline structure of mathematical metaphors, the characteristics or attributes of elements of reality that have been pushed aside by the mathematical-metaphorical models are likely to be those which are not amenable to the mathematical procedures of theorem and proof. However, these might also be those characteristics or attributes which emerge with the most force when a fact or experience is associated not with the precision and cleanness of mathematical objects but with the confusion and imprecision of the human action represented in the financial economic reality. A fact or experience of the nature of the financial crisis foregrounds just those characteristics or attributes of human action that are relegated by mathematical-metaphorical models. The result is a severe salience imbalance that renders the metaphors of the prevailing orthodoxy anomalous or otherwise might be considered to fracture the mapping of characteristics or concepts that formed the basis for the comprehension of the mathematical-metaphor as a meaningful contribution to the discourse of financial economics.

The crystalline structure of mathematical-metaphors and metaphor within metaphor that constitutes the prevailing orthodoxy of modern financial economics has always been characterised (as indeed it must be if it is to be non-literal at all) by a salience imbalance between characteristics of topic (the financial economic reality) and vehicle (mathematical objects). The highly salient features of

[3] See Skousen (1994, p.232) who states, “Financial markets represent human action.”

[4] Whether any elements of the financial economic reality are reflected accurately in the orthodox theory is debatable.

mathematical objects are not directly applicable to and have a low salience in the list of features of the financial economic reality. Despite this, the mathematical-metaphorical models are accepted as meaningful contributions to discourse because the diagonality of attributes, whilst high, did not impede a mapping of attributes or concepts between topic and vehicle by those readers or listeners in possession of the appropriate set of associated commonplaces. A fact or experience of the nature of the financial crisis reduces the salience of features of the mathematical objects in the list of features of the financial economic reality further and, by simultaneously foregrounding or enhancing the salience of other (non-mathematical) features of the financial economic reality, initiates a crisis of metaphor or a severe salience imbalance that fractures the mapping between topic and vehicle. The prevailing orthodoxy has experienced a financial crisis of metaphor.

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