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Modern Finance, Methodology and the Global Crisis

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Abstract

The conceptually unified theoretical core of modern finance, which includes the efficient market hypothesis, the CAPM, the Modigliani-Miller theorem and the Black-Scholes-Merton approach to option pricing, has been instrumental in the growth of the financial services industry, financial innovation, globalisation, and deregulation. The elevation of finance to the stature of a scientific discipline was successful in rendering irrelevant the long-standing moral concerns associated with capitalism and laissez-faire. This success was somewhat of a paradox, since the core theories/theorems were based on wildly unrealistic assumptions and did not stand out for their empirical strength. Overcoming this paradox required a methodological twist, whereby theories were devised to create rather than to interpret or predict reality. This view led to a series of financial practices that increased the fragility and vulnerability of financial institutions, setting the context for the occurrence of financial crises including the recent one.

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Introduction

Financial crises, from the Tulipmania and the South Sea Bubble in the 17th and 18th centuries to the recent one initiated with sub-prime lending, are inexorably related to processes of mispricing and misperception of risk based on individual decision-making, in the context of innovation combined with loose and uncoordinated financial regulation. In all of those processes there are purposeful actions of market insiders to gain from the excesses of market euphoria, and as such financial booms and busts should be seen as intrinsic to the way in which the private sector promotes wealth accumulation and, in some cases, structural change. After all the collapses, there are repeated calls for drastic in-depth financial reform, which may be effective, as in the case of the 1929 crash, or fruitless, as in the Savings and Loans crisis. Significant reform, however, must result from a careful rethinking of the theoretical and methodological foundations that were at the heart of the policies that led to the crisis.

The problem is that the current crisis has made no dent in the very conceptual foundations that provided the justification for the processes of mispricing of risk, which in the first place, led to the gestation and consecration of the crisis. Indeed, the conceptual foundations of finance and their policy implications are viewed by the mainstream as having little relevance for an understanding of the current crisis situation.

This paper takes the contrary view. It argues that ideas matter and that these shape to a great extent the policy orientation of institutions, including financial institutions, and the conduct of economic agents. Whatever their origin, their conceptual formulation (whether formal or not) and their postulated transmission mechanisms, they are inexorably linked to methodological issues and concerns. It would not be an exaggeration to argue that many key ideas in economics and finance sprung from concerns with methodology.

The importance of methodology is illustrated by the 2007-2008 global economic crisis, which is from our point of view, partly a by-product of the development of the theories of modern finance that sought to provide a ‘scientific foundation’ for the actions and behaviour of economic agents. The scientific foundation expressed in hypotheses such as: the random movement of asset prices; the stationarity of returns; a definite linear relationship between risk and return; the irrelevance of finance—under very specific assumptions—to investment decisions; or the possibility to create a risk-free portfolio always; etc., gave legitimacy to capital and stock market activity within a free market economy. It sought to prove that no agents could obtain ‘excess’ profits within this institutional framework, and the creation of a pyramid of financial assets and innovation was a good thing as it could eventually lead to the elimination of risk.

Viewed in the light of the history of economic and financial thought, scientific finance was a crowning achievement to separate *laissez-faire* from moral issues, a pervasive concern present since at least the 16th century, by extracting the acquisitive nature of economic behaviour from the workings of the free market economy.

However, the “wildly unrealistic assumptions” of the theories and the fact that these did not provide fertile ground to empirical corroboration proved to be an obstacle to their consideration as legitimate science. A way to overcome this obstacle was to impose a methodological twist whereby theories, instead of interpreting and predicting reality, were conceived to shape and transform reality. This eventually led to practices by financial institutions that in fact amplified risk as well as financial and real fragility.

The remainder of the paper is divided into five sections. The following two sections present the main building blocks of modern finance, and shows that their core propositions have a common conceptual and methodological unity. The third section shows that these theories had an important influence not only on the growth and development of the financial services industry, but also in promoting the process of financial liberalization and deregulation. The fourth section argues that modern finance is an offshoot of Arrow-Debreu General Equilibrium theory, and as such was seen as scientific by the economics profession. This permitted to render irrelevant the long-standing moral concerns associated with economic and commercial activity under capitalism and *laissez-faire*. The elevation of finance to the status of legitimate science, on the other hand, required a methodological shift whereby theory was devised to shape reality. In other words, as Veblen said in a different context, invention is the mother of necessity; the invention of modern finance

led to the “need” for a series of financial products and practices that led to an increase in financial fragility and the chances of a crisis. The final section provides an assessment of implications and lessons to be drawn from this methodological twist, which are highly relevant for an understanding of episodes such as the global crisis (2007-2008).

The core components of modern finance

The core of modern finance can be encapsulated in four components, namely: the efficient market hypothesis (EMH); the trade-off between risk and return exemplified by the Capital Asset Pricing Model (CAPM); the Modigliani-Miller Theorem (MM); and the Black-Scholes-Merton (BSM) approach to option pricing.²

The efficient market hypothesis (EMH) is the basis for the three other components of the core. It was formulated initially in its strong form stating that security (asset) prices fully reflect all available information.³ This excludes the possibility that trading systems such as the stock market ‘based only on current available information . . . have expected profits or returns in excess of equilibrium expected profit or return’⁴. Formally this is stated as follows:⁵

$$(1)E(p_{t+1} / I_t) = (1 + r_{it})p_t \Leftrightarrow p_t = \frac{E(p_{t+1} / I_t)}{(1 + r_{it})}$$

where,

E = mathematical expectation.

I_t = set of information at time t .

p_t, p_{t+1} = price of a security i at time t and $t+1$. p_{t+1} is a random variable.

r_{it} = percentage rate of return on the security i at time t .

As a result, on average, asset prices cannot be too low or too high and will adjust rapidly to reflect new information, and they will behave randomly. Prices are equal to their fundamental value and thus investors receive what they pay for.

Two other variants of the EMH include the semi-strong and weak-form efficiencies. The semi-strong version states that current prices fully reflect all publicly available information. Finally the weak form states that the current price fully incorporates past information.⁶ In any case, these two variants do not alter in any significant way the fundamental implications of the strong form of market efficiency. Since security prices

behave randomly, no matter the variant of the market efficiency hypothesis, the best predictor of tomorrow's prices are today's prices and excess profits are ruled out.⁷

The main implication of this particular view of market efficiency is that agents cannot predict market prices, since random shocks to preferences, endowments and technology would lead to unpredictable changes in prices. In terms of market applications, this would suggest that an investor would have no capacity of beating the market in a persistent way, and that investing in index funds would be as good as any other strategy. According to the EMH, success stories, like Warren Buffett's, are just a fluke.

The second component of the core of financial economics is the relationship between risk and return expressing the fact that higher risk must be accompanied by a higher expected return. In other words, in order to obtain higher returns, an investor must be willing to accept greater risk. This follows from the fact that utility theory assumes that investors are risk-averse by postulating concave utility functions or equivalently convex indifference curves.⁸

The analysis of the relationship between risk and return is founded upon the explanation of the risk premia (the difference between expected returns and the riskless rate of interest). The Capital Asset Pricing Model (CAPM) is one of the best-known approaches.⁹

The CAPM is an extension of Harry Markowitz's mean-variance portfolio model.¹⁰ Markowitz's model argues that given the risk-averse characteristics of agents, they focus only on the mean and variance of their returns. In particular, investors choose portfolios to minimize the variance of returns, which is the measure of risk, for a given expected return and maximize expected returns for a given risk (shift to footnote) (Fama and French, 2003). The CAPM analyzes the relationship between risk and return under conditions of market equilibrium. In the CAPM, portfolio optimizing agents meet in the marketplace, their interaction drives prices to market equilibrium, and they agree on the joint distribution of asset returns. Formally, the CAPM can be stated as follows.

$$(2)r_i - r = \alpha_i + \beta_i(r_m - r) + \varepsilon_i$$

where,

r_i = return on security i .

r = return on a risk free security which is uncorrelated to that of the market (i.e., government bond).

r_m = return of the market portfolio.

$$\beta_i = \frac{\text{cov}(r_i, r_m)}{\sigma^2(r_m)}$$

Taking expectations in (2) and assuming that $E(\varepsilon_i)=0$ as required by equilibrium conditions and that

$$E(\varepsilon_i) = 0,$$

$$(3)E(r_i - r) = \beta_i E(r_m - r)$$

$E(r_i - r)$ = the security/asset risk premium.

$E(r_m - r)$ = the market risk premium.

According to Equation (3), the return of an asset above that of a risk-free asset such as a government bond, that is, the premium of the asset, is proportional to the Beta statistic. Beta is a measure of the elasticity of the rate of return of an asset with respect to that of the market, that is, its systematic risk. Thus, according to the CAPM, assets with higher systematic risk have a higher return than do assets with lower systematic risk, and that assets with the same systematic risk should give the same return. The importance of CAPM is that it allowed financial markets to quantify the risk of a portfolio.

The third component of the core of financial economics is the Modigliani-Miller theorem (MM). It states that under certain assumptions (the financial markets work perfectly, there are no taxes and no bankruptcy costs, among others) the way in which a firm finances its real activities, say whether with equity, debt or a combination of both, does not affect the cost of capital and has no bearing on its own market value or on the production and consumption decisions of other economic agents. As put by Modigliani (1980: xiii):

“...with well-functioning markets (and neutral taxes) and rational investors, who can ‘undo’ the corporate financial structure by holding positive or negative amounts of debt, the market value of the firm – debt plus equity – depends *only* on the income stream generated by its assets. It follows, in particular, that the value

of the firm should not be affected by the share of debt in its financial structure or by what will be done with the returns – paid out as dividends or reinvested (profitably).”

Thus, investment decisions are independent of finance or to put it another way, finance is irrelevant to investment decisions. This can be stated in terms of a firm’s average cost of capital, which is shown to be equal to the real rate of return on capital and independent of the firm’s capital structure.¹¹ Assuming that in equilibrium, returns on securities (say, r_i) are a random variable following a stationary process¹², and are homogeneous among all assets of a given class and equal to the average cost (the ratio of its expected return to the market value of all securities), the Modigliani & Miller Theorem¹³ formally state the irrelevance proposition as,

$$(4) \frac{X_j}{(S_j + D_j)} = r_k$$

where,

X_j = expected returns on the firm's assets.

S_j = market value of the firm's shares.

D_j = market value of the firm's debt.

r_k = expected rate of return of class of shares k.

The Black-Scholes-Merton option-pricing model (BSM) is the final and culminating pillar of modern finance. An option is defined as a contract between a buyer and a seller, which gives the buyer the right, but not the obligation, to buy or sell a particular underlying asset within a certain time period at a specified price (i.e., the strike price or the price at which the contract can be exercised). The underlying asset in question can include common stock, property, or a physical commodity. Central to option pricing theory is the determination of the cost or value of the option.

The value can depend on many factors including the current market price of the underlying asset, the exercise price of the option, the maturity date of the option contract, the speculative premium of the option (estimated deviation with respect to the price of the underlying asset over the life of the option), and the risk-free interest rate. Using these variables, Black, Scholes and Merton “improved on an old mathematical formula and made it compatible with Gaussian general financial equilibrium theories”.¹⁴ The formula already

existed, but was not compatible with the risk-free general equilibrium environment, and that was the contribution of Black, Scholes and Merton.

Their model showed that it was possible to construct a riskless portfolio through dynamic hedging, that is, by taking positions in bonds (cash), options, and the underlying stocks. According to their reasoning, changes in the value of the option would be offset by equal changes in the value of the underlying stock and cash.

Formally, assume a three asset world composed of a bond, a stock, and a derivative. Each asset price follows a distinct process. The bond process is deterministic and the change in the value of the bond (B) equals the opportunity cost of investing the funds equivalent to the value of the bond in a risk-free asset.¹⁵ That is,

$$(5)dB = rBdt$$

where, B = bond; r = risk free rate of return.

For its part, the stock follows a stochastic process and the change in the value of the stock (S) follows a geometric Brownian motion,¹⁶

$$(6)dS = \mu Sdt + \sigma Sdz$$

where, S =stock value; μ and σ are the first two moments of a log normal probability distribution representing the drift term and the volatility. z captures the brownian motion.

Finally, the value of the third asset, the derivative (D), depends on a set of variables including among others, that of the stock (S), the risk-free rate of interest (r), and the mean and standard deviation of the stock (μ and σ respectively). Assume for simplicity that it depends solely on S (the stock or underlying asset) and t (time), or in other words that the value of the derivative at time t is equal to:

$$(9)D_t = D(t, S_t)$$

Using a stochastic version of the ‘chain rule’ known as Ito’s Lemma, the change in the value of the derivative is guided according to the following process,

$$(10)dD = \left(\frac{\partial D}{\partial t} + \frac{\partial D}{\partial S_t} \mu S_t + \frac{(S_t \sigma)^2}{2} \frac{\partial^2 D}{\partial S_t^2} \right) dt + \frac{\partial D}{\partial S_t} \sigma S_t dz$$

According to (10), the change in the value of the derivative (D) is a function of the value of stock (S) and its changes (dS), its volatility (σ) and drift (μ) and of the changes in the value of the derivative itself with respect to time and with respect to changes in the stock (S).

Given these three processes that determine the change in the values of the bond (B), the stock (S) and the derivative (D), the idea behind Black and Scholes is to form a portfolio (P_t) combining two of these assets (say the bond (B) and the stock (S)) that is risk-free. In other words, the idea is to create a portfolio that has no 'z' Brownian motion term; a portfolio that is deterministic (i.e., that has no stochastic term). Let then P_t be comprised partly of stock and partly of derivative,

$$(11) P_t = \alpha S_t + \beta D_t; \quad \alpha + \beta = 1$$

and by total differentiation,

$$dP = \alpha dS + \beta dD$$

The substitution of dS (6) and dD (10) into (11) eliminating 'z' and postulating that a risk-free portfolio earns the risk-free rate of interest leads to the well-known Black-Scholes equation and, most importantly, its solution.

The solution states that the value of an option is a function of six known arguments: (i) the current market (spot) price of the underlying asset (S_t); (ii) the price level at which the option holder has the right to buy or sell the underlying asset (the strike price) (K_t); (iii) the time until the option expires (the time to maturity); (iv) the risk-free rate of interest (rate of return) (r); (v) the volatility of the price of the underlying asset (σ); (vi) the probability derived from a Normal distribution that at maturity the option will be exercised ($N(\cdot)$). That is,

$$(12) D = f(S, K, r, \sigma, M, N(\cdot))_{17}$$

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According to (12), the value of a derivative (option) varies positively with greater volatility, time to maturity, and with the price of the asset. The value of the derivative is negatively related to the strike price and the rate of interest. In the original derivation, volatility (σ) ('the key to price derivatives and options') and the rate of interest were assumed constant. Moreover, the value of the underlying asset changed smoothly over time.¹⁸

The Conceptual and Methodological Unity of the Theorems/Theories at the Core of Finance

The four building blocks of modern finance were developed separately, at different stages of thinking in financial economics, under different circumstances and for different purposes.¹⁹ Nonetheless, these four theorems share, in the main, a common set of fundamental assumptions (See Table 1 below).

These theorems are grounded in general equilibrium theory and their conception of market efficiency is in line with that of the Arrow-Debreu model. More specifically, they assume the following:

- Some form of existence of perfect capital markets—no taxes, no transactions costs and in the case of MM, also no danger of bankruptcy;
- Agents have equal access to information and capital markets;
- Agents and prices adjust rapidly and continuously to new information;
- Decisions are made solely on the basis of expected values and standard deviations of the returns on the portfolios; and
- All agents have homogenous expectations.

Their conceptual similarity allows them to be articulated to form a coherent framework of analysis with definite implications for the practice of finance.

Taken jointly, this core of finance states that any asset (whether of the standard type such as the common stock or the more sophisticated kinds such as options and derivatives) is tradable. It has a price and a rate of return determined in an efficient market (Black-Scholes and EMH).

In such a market, there are no arbitrage opportunities and the prices must be equal to the present discounted value of expected future payoffs over the asset's life (EMH, CPM, MM, Black-Scholes-Merton). The expectation of future payoffs follows a Martingale probability, that is, the best predictor of the future stream of payoffs are the current ones and the rate of discount is the riskless rate of return (EMH, CPM, MM, Black-Scholes-Merton).

The riskless rate of return obtains because the risk of any asset is independent of how the asset is financed (MM) and is determined only by systematic risk (CAPM). However, through hedging and thus increased trade in financial instruments (Black-Scholes), the systematic risk can be reduced significantly, and all assets can be made risk-free.

Table 1: Main underlying assumptions of the core theorems/theories of modern finance

Main assumptions	Theorems/hypothesis			
	EM	RR	MM	BSM
Normal utility maximizing risk averse agents	X	X	X	X
Agents have rational expectations	X	X	X	X
Markets are frictionless and information is costless and simultaneously available to all agents	X	X	X	X
Agents update their expectations continuously and appropriately to new relevant information	X	X	X	X
Investing decisions made on the basis of expected values and standard deviations of the returns on the portfolios	X	X	X	X
Investors are price takers	X	X	X	X
Prices adjust rapidly but smoothly to reflect all information	X	X	X	X
Investors have homogenous expectations	X	X	X	X
All assets (shares) are marketable and are infinitely divisible	X	X	X	X
Unlimited lending and borrowing at the constant risk-free rate	X	X	X	X
Stock prices follow a random walk	X	X	X	X
No taxes		X	X	X
No danger of bankruptcy			X	
Investment decisions are independent of how investment is financed			X	
Asset returns are (jointly) normally distributed random variables	X	X	X	X
Correlations between assets are fixed and constant	X	X	X	X

Notes: EM = Efficient market hypothesis; RR = Risk and return (CAPM); MM = Modigliani-Miller theorem; BSM = Black-Scholes-Merton equation. Source: Jarrow (1994).

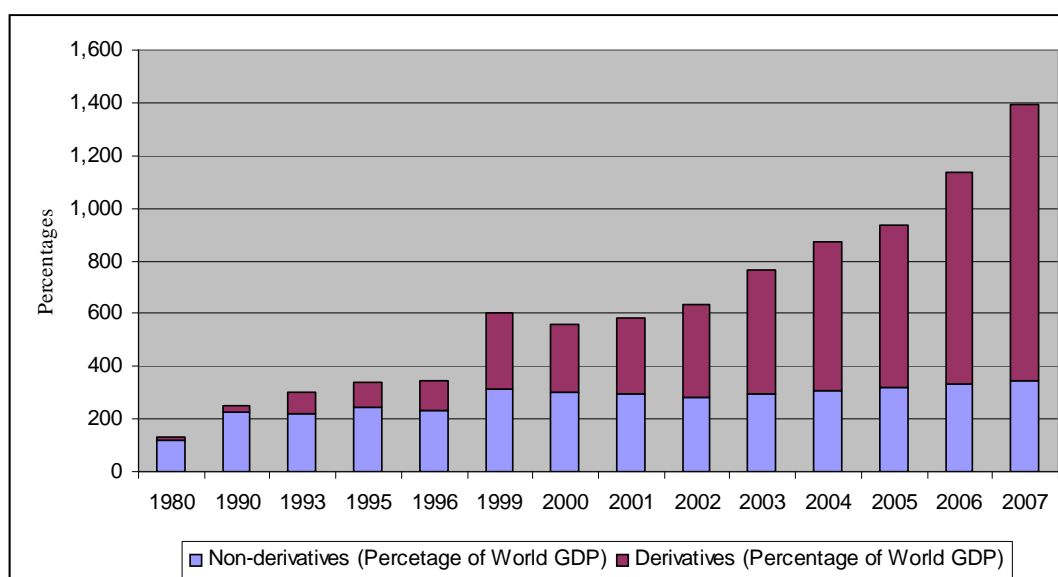
Modern Finance and the Real World

The core theorems of finance provide a premier and perhaps unique case where academic research has affected to a great extent real world views on finance, research on financial economics as well as the daily practice of all those engaged in financial transactions. The influence and interaction between financial theory and the growth of finance schools and that of the financial sector in terms of size, volume and instruments is well documented.

In the past five decades, the output of business masters degrees has expanded considerably. In the mid-1950s, the annual output of US business masters was a little over 3,000. Close to three decades later, in 1981, the number of business masters degrees reached 55,000.²⁰ By 1997-1998, the number had expanded to reach over 100,000. In comparative terms to other professions, the number of MBA degrees surpassed the combined output of lawyers and medical doctors in 1980, and was double the BAs awarded in engineering in 2000.²¹ In 2001, as a sign of the times, Bush became the first MBA graduate to assume the US presidency. The expansion of business schools was not unique to the United States as attested by the experience of a similar trend in other countries.²²

Finance theory not only encouraged the rise in business schools, but also was instrumental in the growth and extensive development of the financial sector, in particular since the middle of the 1980s. Available data for the period 1980-2007 show that in 1980, the value of the stock of financial assets, including derivative contracts, was slightly above that of GDP (129% of GDP including derivatives). In 1990, the value of the stock of financial assets was more than twice that of GDP (253% including derivatives). By 2001, the value of the stock of global financial assets was roughly six times that of World GDP, and by 2007 it represented 13 times the value of World GDP (see Figure 1 and Table 2 below).

Figure 1: Global Financial Depth
(Value of the stocks of assets as percentage of World GDP, 1980-2007 (Selected years))



Source: McKinsey Global Institute (2006 and 2009).

The rise in global financial depth is explained mainly by the exponential growth in derivatives. Between 1980 and 2007, derivative contracts expanded from US\$1 trillion to roughly US\$600 trillion. In percentage terms, derivative contracts represented 7% of the global stock of financial assets in 1980 and 28% by the middle of the 1990s, becoming the most important contributor to financial asset growth. In 2007, the value of derivative contracts represented 75% of the global stocks of financial assets (see again Figure 1 above and Table 2 below).

Table 2: Global Financial Assets by Category
(in US\$ trillion, and as percentages of the total and of World GDP, 1980-2007)

	1980	1990	1993	1995	1996	1999	2000	2001	2002	2003	2004	2005	2006	2007
Global financial assets by category (US\$ trillion dollars)														
Equity securities	3	10	14	18	20	36	37	33	26	33	38	45	54	62
Private debt securities	2	10	12	14	16	20	24	27	28	31	34	37	42	48
Government debt securities	2	9	11	13	13	14	17	18	20	22	24	27	28	29
Bank deposits	5	19	17	25	20	25	34	36	38	40	43	46	51	56
Non-derivatives (US\$ trillion)	12	48	54	70	69	96	112	114	112	126	139	155	175	195
Derivatives (US\$ trillion)	1	6	20	27	35	88	95	111	142	197	259	299	418	596
Total (US\$ Trillion)	13	54	74	97	104	184	207	225	254	323	398	454	593	791
Global financial assets by category (As percentage of the total)														
Equity securities	21	19	19	19	19	20	18	15	10	10	10	10	9	8
Private debt securities	13	19	16	14	15	11	12	12	11	10	9	8	7	6
Government debt securities	17	17	14	13	13	8	8	8	8	7	6	6	5	4
Bank deposits	42	35	23	26	19	14	16	16	15	12	11	10	9	7
Derivatives	8	11	27	28	34	48	46	49	56	61	65	66	70	75
Total (percentages)	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Global financial assets by category (As percentage of World GDP)														
Non-derivatives (Percentage of World GDP)	119	226	219	246	231	315	303	296	281	298	305	319	335	343
Derivatives (Percentage of World GDP)	10	27	83	95	117	289	257	288	356	466	569	615	799	1,049
Total (Percentage of World GDP)	129	253	302	342	348	603	559	584	637	764	875	934	1,134	1,393

Source: On the basis of McKinsey Global Institute (2006 and 2009).

The unprecedented expansion of derivatives was accompanied by a shift away from banks and towards market institutions as the main financial intermediaries. In 1980, the value of equity and private debt securities equalled that of bank deposits (US\$5 trillion). By 2007, the value of equity and private debt doubled that of bank deposits (US\$110 trillion and US\$56 trillion respectively).

The contribution of the modern theories of finance to the development of financial derivatives is recognized in the communiqué of the Committee, which awarded the Nobel Prize in 1997 to Merton and Scholes.

Burton R. Rissman, the Counsel of the Chicago Board Options Exchange, which was one of the “first modern financial derivatives exchanges and a prototype of other derivative exchange centers such as the London International Financial Futures Exchange (LIFE) and the Deutsche Terminborse (Eurex),” explains the influence of financial theory on practice. As he puts it, “the Black-Scholes was really what enabled the exchange to thrive”.²³

However, the influence of option price theory was not only limited to the development of derivatives but also had an important impact on the entire financial services industry. In his Nobel Lecture, Merton emphasizes that the influence of option price theory was not limited only to the derivatives markets. In his words:²⁴

“The influence of option price theory on finance practice has not been limited to financial options traded in markets or even to derivatives securities generally. ... Option pricing technology has played a fundamental role in supporting the creation of new financial products and markets around the globe. In the present and in the impending future, that role will continue expanding to support the design of entirely new financial institution, decision-making by senior management, and the formulation of public policy on the financial system.”

Finally, and most importantly, Merton argues that, while cognizant of the feedback between financial theory and financial innovation, the expansion of the derivative industry was also largely accountable for the rate and pace of financial globalization. It is worth quoting him at length on this point:²⁵

“A central process in the past two decades has been the remarkable rate of globalization of the financial system... This was made possible in large part by the derivative securities functioning as ‘adapters’. In general, the flexibility created by the widespread use of contractual agreements, other derivatives, and specialized institutional designs provides an offset to dysfunctional institutional rigidities. More specifically, derivative-security contracting technologies provide efficient means for creating cross-border interfaces among otherwise incompatible domestic systems, without requiring widespread or radical changes within each system. For that reason, implementation of derivative-security technology and markets within smaller and emerging-market countries may help form important gateways of access to world capital markets and global risk-sharing. Such developments are not limited only to the emerging-market countries with their new financial systems. Derivatives and other contracting technologies are likely to play a major role in the

financial engineering of the major transitions required for the European Monetary Union and for the major restructuring of financial institutions in Japan.”

While the quotes of Merton and Counsel of the Chicago Board Options Exchange refer to the Black-Scholes-Merton equation for option pricing, the rest of the theories also had important practical implications. The CAPM is known to have provided the foundation for ‘a vast industry in portfolio management’.²⁶ The MM theorem also had important ramifications for the choice of the composition of capital structure and its relation to the asset side of firms. Moreover, since the CAPM and MM theorems were essential to the development of the Black-Scholes-Merton approach²⁷ and the EMH is a central element of the rest of the components of the core, they certainly contributed to the spur for deregulation, liberalization and growth of financial markets.

Invention is the Mother of Necessity

From our point of view, the practical triumph and significant influence of the core financial theories can be explained, because they provide a successful attempt to render irrelevant the long-standing moral concerns associated with economic and commercial activity under capitalism and laissez-faire.

Historically, the wealth-gathering and money-making activities associated with capitalism and laissez-faire were looked upon with disdain and suspicion and stood lower than other activities in the scale of societal values. Political economy, and its underlying belief system, played a fundamental role in making the pursuit of mercantile and banking activities appear legitimate.

This was accomplished initially by showing the compatibility of self-interest with the well-being of society as epitomized by Adam Smith’s ‘invisible hand’ metaphor. In a similar way, it was argued, as demonstrated by Hirschman (1977), that an acquisitive society could harness dangerous passions that could flourish under capitalism such as greed and avarice into being benign interests. This line of argument in defence of the free market permeated economic thought well into the 20th century as shown by the following quote of Keynes (1936: 374):

“Dangerous human proclivities can be canalized into comparatively harmless channels by the existence of opportunity for money making and private wealth, which, if they cannot be satisfied in this way, may find

their outlet in cruelty, the reckless pursuit of personal power and authority and other forms of self-aggrandizement.”

A further step in this direction was undertaken in the 19th century by the Marginal Revolution theorists, mainly by William Stanley Jevons and León Walras, who explicitly and definitively removed moral issues and the problem of good and evil from the concerns of political economy. In order to become a science as warranted by Jevons and Walras, political economy had to exclude those issues not amenable to the calculus of pain and pleasure or to utility analysis.

In this regard, in his *Elements* (1952: 21), Walras explains that there is no point in considering the morality or immorality of the need satisfied by a good. As he puts it, a substance may be used by a doctor to heal a patient or by a murderer to poison his family; but whether the substance should be used to heal or kill is a matter of indifference for political economy. As pinpointed by Walras, the substance is useful in both cases and in fact may be more useful to kill than to heal.

Modern finance sharpened this line of thought by making moral concerns an irrelevant issue to the understanding and workings of economic and commercial activity under a free market regime. It accomplished this by elevating finance to the stature of a scientific discipline. This was made possible, to some extent, because modern finance freeloaded on the prestige of Arrow-Debreu, with which it shares several assumptions including arbitrage and informational efficiency, and because the Nobel committee was “largely responsible for giving credence to the use of the Gaussian Modern Portfolio Theory” by giving prizes to several of the authors that developed theories described in the previous section.²⁸

As explained above, one of the main implications of all the components of the core is that no market participant could beat the market and make excess profits, and on average every market participant receives what he pays for. Since no market participant could predict nor influence the market for securities, fluctuations in prices were purely exogenous to economic behaviour and external to the financial system. Also, given information, initial endowments and the preferences of participants, all prices are equilibrium prices, and any kind of regulation would distort market efficiency.²⁹ Finally, it could be shown that financial market activity could create risk-free portfolios of financial assets, no matter their characteristics.

This view is reminiscent of the approach taken by the Marginal Revolution theorist, William Stanly Jevons, which understood market forces to lead to a configuration ‘insuring maximum happiness ... that could only be deflected’ by exogenous forces outside human activity and control such as solar cycles.³⁰ As a matter of curiosity, Jevons’ sunspot theory provided the basis for the computation of the Dow Jones Industrial Average in 1896 by Charles Dow, and for the introduction of informational efficiency to describe stock market behaviour.³¹

In other words, modern finance gave legitimacy to stock and capital market activity by extracting the acquisitive nature from the workings of the free market and in general of capitalism. Moral issues simply had no place in this scientific approach to finance. The statement of the former counsel of the Chicago Board Options Exchange puts it succinctly with respect to the Black-Scholes-Merton equation and its influence on the view of derivatives and option prices as casino-like activities: “It wasn’t speculation or gambling, it was efficient pricing. I think the SEC [Securities and Exchange Commission] very quickly thought of options as a useful mechanism ... and it’s probably the effect of Black-Scholes” (apud McKenzie, 2009: 18).

The influence of modern theories of finance on the change in the perception of the acquisitive nature of market activities was not limited to the stock and capital markets but, in fact, permeated all other economic activities. Indeed, the formulation, formalization and development of the main tenets of modern finance including informational and arbitrage efficiency, predated the Rational Expectations Revolution which gave birth to modern macroeconomics. These assumptions are at the heart of modern macroeconomics, and it is difficult to assume that agents form their expectations rationally without at the same time assuming that markets, asset, goods and factor markets are also efficient.³²

As put by Fama (2007): “...rational expectations stuff is basically efficient markets; they’re pretty much the same thing. If you are talking about the macroeconomy, I don’t see how you can avoid financial markets.” And further: “you can’t test models of market equilibrium without market efficiency because most models of market equilibrium [and we assume this includes New Classical models] start with the presumption that markets are efficient. They start with a strong version of that hypothesis, that everybody has all the relevant information. Tests of market efficiency are tests of some model of market equilibrium and vice versa. The two are joined at the hip.”

Legitimizing the theories of modern finance by elevating them to the rank of a scientific discipline requires not only the formalization of theory, as epitomized by the introduction of the Brownian equation of motion as an integral part of the Black-Scholes-Merton approach to option pricing, but also showing that these theories are useful in practice.

Yet as explained above, their assumptions are simply very unrealistic and stringent as recognized by the authors themselves.³³ Also, these theories are not known for their capacity to explain the past or to replicate the workings of the real world. In general, the empirical validity of all of these theorems and their propositions has been a constant source of controversy, and it is not uncommon to find critical and harsh judgment of their practical applicability (see Table 3 below).

In short, and as put by Bossaerts (2002: x): “Modern finance has generated a set of formal mathematical models of the workings of financial markets that certainly excel in terms of mathematical elegance. But abstract beauty and logical appeal do not guarantee scientific validity.”

The EMH is a case in point. Over the years, the empirical evidence for the EMH has been shown to be less and less convincing. Shiller (1981) has shown, for example, that even though financial theory argues that stock prices are the current value of expected dividends, the evidence shows that the former are considerably more volatile than the latter. The critiques of financial theory within the mainstream are based on what has been called behavioural finance.

The main critique of behavioural finance is that agents are not completely rational, and if one adds the developments of information economics, one would conclude that market inefficiencies are somewhat pervasive and that bubbles, and crashes, should be relatively common features of the economy.³⁴ At heart, behavioural economics aims at greater psychological realism than the standard neoclassical models. Behavioural models start from empirical regularities and try to find assumptions that would lead to that particular result. In general, the empirical regularity implies that agents follow a simple rule of thumb and then derive the consequences, which may not be efficient in the aggregate.

Behavioural finance results undermine the basis for some of the EMH conclusions; however, behaviourists still would agree that informed investors would be unable to beat the market, even if markets are less than

rational. The important implication is that bureaucrats who try to regulate the market would not be better than markets in evaluating risk, and as a result a hands-off policy would still be recommended.

This paradox represented an important obstacle to their consideration as ‘legitimate science’. The most common way to overcome this obstacle is to attempt to corroborate theories through ‘laboratory’ experiments. An illustrative case in finance involves the testing of the Modigliani-Miller theorem through a general equilibrium approach, involving the evaluation of firms’ equity with different capital structure by experimental subjects.³⁵

An extreme example of this line of thought in the case of general equilibrium theory is provided by Lucas (1987: 224-227), who cites experimental examples with pigeons undertaken at the Texas A&M University to see to what extent their choice patterns satisfy the axiom of weak revealed preference. “This is to illustrate the point that, as economic behaviour in pigeons is determined by an adaptive process, why not extend it to the understanding of human behaviour in actual market situations”.

Table 3: A summary of the empirical evidence of the theories/theorems of modern finance

Efficient market hypothesis
<p>In the period running from 1965 to 1985, the EMH became progressively and widely accepted in financial circles at least in its weak and semi-strong forms. It was common belief that new available information was rapidly incorporated into asset prices and securities market behaviour; that current information could not be used to predict future excess returns; that technical analysis did not provide additional useful information and that agents in financial markets could outperform the market in a systematic way. The following decade (1986-1997) witnessed a mounting challenge to the EMH and the concept of rationality in financial markets and participants, spurred by the detection of a series of ‘anomalies’ in the functioning of capital markets. These include, among others, the January, weekend, seasonal, size, and P/E effects. These anomalies questioned some of the main testable hypotheses of the EMH including: (i) that returns are not predictable on the basis on past/current information; (ii) that new and relevant information is rapidly incorporated in prices; and (iii) the non-existence of volatility in share prices relative to fundamentals and of return indicating the presence of irrationality in market behaviour. Thereafter, the criticism and challenge to the EMH and the notion of efficiency in markets became further entrenched by the rise of different approaches to the understanding of financial market behaviour, notably by Prospect Theory and more generally Behavioral Finance, and the recognition that financial crises are a recurrent phenomenon of market-oriented economies.</p>

Modigliani-Miller Theorem

The Modigliani-Miller theorem has both adherents and deterrents. The former provide empirical evidence suggesting that there is little association between leverage (or with the capital structure of a firm) and the costs of capital. From here it follows that investment decisions are independent of the firm's finance. The deterrents argue that value and leverage are, in fact, correlated: the firm's value increases with leverage. Nonetheless, it is fair to state that, in fact, the Modigliani-Miller theorem is difficult to test and may not provide empirically-testable propositions. This was recognized by Miller (1988) in reference to the initial approach in testing that theorem jointly with his co-author Modigliani. As he puts it (p.103): "we devoted more than a third of the original paper (plus a couple of follow-up studies notably Modigliani-Miller (1966) to empirical studies of how closely real world market values approached those predicted by our model. Our hopes of settling the empirical issues by that route, however, have been largely disappointed." More recently Myers (2001: 85-86) has stated that the Modigliani-Miller's propositions while not controversial are 'exceptionally difficult to test directly.' The difficulty to test the theorem can explain the assertion by Azarmi *et al.*, (2005: 32) 'that so far there is no statistically satisfactory empirical test of MM's value-invariance proposition.' More recently Qiu and Mahagaonkar (2009) conclude that the evidence is largely inconclusive.

CAPM

The empirical validity of the CAPM derived from the hypothesis that 'assets must be priced so that a market portfolio is mean-variance efficient'. A mean-variance efficient portfolio implies (i) a linear relationship between expected returns and market betas; (ii) a positive risk premium; (iii) the expected return on assets whose returns are uncorrelated with a market portfolio is equal to the risk-free rate. The early empirical literature on the CAPM dating from the late 1960s to the late 1970s accepted the testable hypothesis (i) and (ii) but rejected hypothesis (iii). Thereafter, the empirical tests questioned the validity of hypothesis (i), challenging the conclusion that market portfolios are M efficient and that market betas are sufficient to describe market returns. Other variables such as size, price ratios and even the influence exerted by investors through purchase of stock or shareholders' resolutions are also important determinants of average market returns. The shared opinion of the empirical validity of the CAPM was recently put forward by Bossaerts (2002: x) in the following way: "there appears to be surprisingly little support for even the most widely used financial model, namely the Capital Asset-Pricing Model...there is little evidence that the theory [asset pricing theory] explains the past, let alone that it predicts the future." In a similar way, Fama and French (2004: 1) state that "the empirical record of the CAPM is poor" and summarize the empirical results stating that the (Ibid.: 27) "Problems are serious enough to invalidate most applications of the CAPM."

Black-Scholes-Merton Model

The Black and Scholes model assumes that the underlying stock (asset) follows a Brownian motion, which implies that the volatility is constant and that returns follow a Gaussian distribution. In practice, it has been shown that returns show excess kurtosis and that their distribution is leptokurtic, which implies higher peaks around the mean compared to normal distribution and thicker tails on both sides of the distribution. In turn, this means that there is a higher than normal probability of big positive and negative returns. That is, extreme returns are more of a possibility than suggested by the assumption of a Gaussian Distribution. Also asset price data show that returns are not independent random variables but can be shown to be correlated. Volatility is variable and cannot be inferred from its past behaviour. The example provided by the Long Term Management Capital Fund discussed in the next section is an illustrative example. The gaps in the empirical application of Black and Scholes to the real world became more obvious following the 1987 stock market crash in the United States.

Selected sources: For the EMH, see Russel and Torbey (2008); Malkiel (2003); and French and Fama (2003; 2004). For the CAPM, see Black, Jensen and Scholes (1972); Blume and Friend (1973); Fama and MacBeth (1973); Basu (1977), Ringanum (1981); Banz (1981); Bhandari (1988); Gibbons (1982); Stambaugh (1982) Statman (1980); Shanken (1985); and Rosenberg, Reid and Lanstein (1985). Evidence supporting the Modigliani-Miller theorem is provided among others by Modigliani and Miller (1958), Miller and Modigliani (1966); and Devenport (1971). Evidence to the contrary includes the studies by Weston (1963); Robicehk *et al.* (1967); Masulis (1980); Taggart (1985); Lee (1987); Israel, Offer and Siegel (1991); and Qiu and Mahagaonkar (2009). For Black-Scholes-Merton theorem, see Trenca and Zoicas-Ienciu (2002); Black and Scholes (1972); Ferguson and Platen (2005); Mckenzie (2005); Vahamaa (2003); and Jarrow (1999).

A more potent route to overcome this obstacle, to definitively establish the scientific character of modern finance was found by Scholes and Merton. It involved a radical and fundamental twist to traditional methodology.

Economic theories, whatever their methodology, are formulated to interpret reality, events or explain types and modes of economic organization or predict behaviour. In one of the earliest methodological essays, Lionel Robbins (1940: 99-100) explains that the nature of economic analysis consists of deductions from postulates derived mainly from ‘universal facts of experience.’ Friedman (1953) saw theory as serving a predictive function. More recently Lucas (1980: 697) understood theory as: “an explicit set of instructions for building a parallel or analogue system – a mechanical imitation economy.”

Contrarily, Merton and Scholes used their model to transform reality, the reality of markets, so that that reality was conceived as an empirical replication of a theoretical construct, and, in this case, of an equation (the option price equation). In a nutshell, Merton and Scholes by logical and methodological construct became market creators. This was made clear in Merton’s Nobel Lecture (1997: 109):

“There are two essentially different frames of reference for trying to analyze and understand changes in the financial system. One perspective takes as given the existing institutional structure of financial service providers ... and examines what can be done to make those institutions perform their particular financial services more efficiently and profitably. An alternative to this traditional institutional perspective – and the one I favour – is the functional perspective, which takes as given the economic functions served by the financial system and examines what is the best institutional structure to perform those functions.”

The Empirical Replication of Theory and its Consequences

The empirical replication of theory requires by logic that reality conform to its assumptions. In the particular case of the Black-Scholes-Merton equation, the replication of its main message, that everything is an asset, every asset has a price and is tradable, and almost any risk is diversifiable through dynamic hedging, demanded that reality conform to the assumption of perfect capital markets (complete markets with no transactions costs).

This required the creation of, at least, as many securities as there are states of nature, that trading in securities must be a continuous on-going and growing activity and that agents must be able to transfer income between the different states of nature by trading in securities. As put by De Goede (2001: 158): “Merton was dedicated to finding the ‘right’ price for all kinds of explicit and implicit uncertainties and called his market vision the ‘financial-innovation spiral’ in which limitless amounts of custom-designed financial contracts spiraled towards the utopia of ‘complete markets and zero marginal transaction costs.’”

The realization of this utopia is only possible in a very particular type of world, an ergodic world. In an ergodic world, time averages obey the central limit theorem so that the trajectory of any variable, say, asset prices or returns, behaves like a stochastic process. Furthermore, averages are time invariant (stationary). Both properties imply that given a sufficient number of independent realizations of an event (random variable), its sample statistics (moments) will converge to their objective (population) Gaussian values (moments).

Limitations imposed by a lack of observations to estimate the population moments are overcome by invoking the Law of Large Numbers. As an illustration, in finance while there are not enough observations to estimate the Gaussian moments associated with every risk of every possible state of nature, risks can be combined so that they observe the Law of Large Numbers and, as a result, they are independent of one another.³⁶ This allows option price theory to be applied, and prices can be obtained for all insurance contracts.

More importantly, ergodicity implies that ensemble, spatial and temporal averages, such as for example asset prices or stock returns, converge over time to the same true mean. This implies that the time-average

is independent of its initial conditions; it is the same for all initial points and thus “forgets” its initial state. In this sense, the future becomes a replica of the past and thus completely predictable.

Table 4: Selected financial strategies and their implications

Financial practices	Purpose and implications
Leverage	<p>It is defined as the ratio of assets over equity. The leverage ratio reflects the extent to which financial intermediaries use debt to finance the acquisition of its assets. The greater is the leverage ratio of a financial intermediary the greater is its level of indebtedness.</p> <p>Relying heavily on debt financing may impact negatively on the credit rating of the investment bank and make it difficult for funds to be raised in the future. In addition, since equity is a cushion against insolvency, the greater is the dependency on debt financing, the smaller is the buffer of the investment bank in question against any unforeseen change in the value of assets. In short, relying heavily on debt finance increases the exposure and vulnerability to illiquidity and more importantly to insolvency.</p>
Off-balance sheet funding	<p>Enables financial institutions to obtain liquidity without recording a liability, improving their debt ratios and expanding their borrowing capacity.</p> <p>Allows asset deconstructing through the creation of a financial asset structure, which is bankrupt remote, (Special Purpose Vehicles) or which is the same thing, legally independent of the risk, quality or continued existence of the originator of the assets in question.</p> <p>Off-balance sheet funding was mistakenly sought to be able to separate the risk of investing in an asset or asset-backed security from the risk associated with the originator of the asset or security and even with the risk of the asset or security themselves.</p> <p>Off-balance sheet funding encouraged excessive risk-taking and simply amplified the risk of financial institutions.</p>
Tranching	<p>A credit enhancement technique that separates securities (mortgage-based assets) according to different categories. Improves the credit rating of assets and lowers their risk.</p> <p>Investors in the tranches of mortgage-backed securities are ensured by the underwriters that “they could always sell-off their position at either the original purchase price, or, at least, at some orderly price change if the market price started to decline below the original purchase price”.³⁷ The techniques for ensuring investors included ‘liquidity puts...and selling and purchasing of tranches to maintain market stability’.³⁸ In the face of falling share prices the accumulation of tranches led to a solvency crisis of the underwriters.</p>

Sources: Pérez Caldentey, Titelman and Pineda (2009); and Davidson (2008).

The belief that the future is perfectly calculable and manageable was inherently present in the ‘safe’ financial strategies pursued by hedge funds and other financial institutions, in the 1990s and 2000s. These included widespread adoption of high levels of leverage by financial institutions in the developed world, in particular

by investment banks and hedge funds, off-balance sheet practices, and the tranching process of mortgage-based assets. In practice, these led to the mispricing and misperception of risk and increased the likelihood of insolvency of financial institutions (See Table 4 above), as shown by the 2007-2008 crisis.

A more specific example of the belief in a calculable future is provided by the risk computations of the Long-Term Capital Management Fund (LTCM).

LTCM used a Value at Risk (VAR) methodology to gauge the amount of equity capital that it needed to hold in order to carry out its trading activities in a solvent manner. According to Jorion (2000), taking into account that the annual average volatility of Standard and Poor's (S&P) 500 stock index between 1978 and 1997 was 15%, the equity capital of LTCM was equal to US\$4.7 billions, and that the positions of the LTCM fund "were allocated so as to maximize expected returns subject to the constraint that the fund's perceived risk was no greater than that of the stock market," LTCM managers arrived at the conclusion in May 1997, that US\$45 million was the required VAR buffer stock to remain solvent.³⁹

The losses later incurred by the LTCM as a result of the Asian and especially Russian crises were simply seen according to their belief in their accurate computations of the future as extremely unlikely. These events led to significant increase in volatility which led to losses surpassing US\$ one billion in one month (August 1998), which could not be supported by its capital base. According the De Goede (2001: 160): "In LTCM's statistical models, such losses were calculated to occur every 800 trillion years or 40,000 times the age of the universe."⁴⁰ In short, the losses that led to LTCM's fall could not have occurred in an ergodic world.

The overall consequence of this methodological twist—the invention of modern finance that led to the creation of new financial instruments—was to promote strategies that have actually created more risk. In that sense, the regulatory failure cannot be separated from the intellectual background that provided the fuel for the incredible expansion of financial instruments.

Also, the question posed by the recent global crisis is not whether we need more and better mathematical models that can deal with the complexity of economic reality⁴¹ or better understanding of the institutional

and historical features of real economies⁴², even though better models are possible and the mainstream lacks the tools for understanding institutional complexity. The problem is at a deeper level than the methodological use, or not, of mathematical modelling.

From our point of view, there is a strong need for discarding the methodological presupposition enshrined by modern finance according to which theory can shape reality, and to recognize that this methodological stance contributed to increasing the power of financial groups at the expense of other groups in society. It should not come as a surprise that the incredible rise in finance was connected with increasing inequality around the globe. This also suggests that the validity of theories that do not recognize the role of social conflict for the determination of income and wealth distribution, as is the case with the mainstream neoclassical theory that is the basis of modern finance, should be seriously questioned. Financial reform can only be effective if the ability of financial practitioners to transform the market to fit their theories is severely constrained.

Conclusion

The interaction of ideas and policies is central to the understanding of the evolution of social and economic change. Ideas shape policy, and the effects of policies on the real world provide a feedback and produce new ideas. The dialectical interaction between financial theory and the policies that shaped financial practices and outcomes is no different from that in other human activities. However, modern financial theory went beyond the conventional methodological stance, according to which theories are built to understand and/or predict reality (which may have indirect implications on how we comprehend and, hence, intervene in the real world), and directly promoted a significant transformation of reality.

The long history of financial institutions in capitalist societies indicates that the new methodological stance should be seen as a new instrument to promote capital accumulation. It should be noted that in the process of creating wealth, capitalism has always had the paradoxical effect of destroying a lot of the pre-existing riches. That is the basis of Marx's view that in capitalism everything that is solid melts in the air, and everything that is holy is profaned, and of Schumpeter's notion of creative destruction. It must also be noted that accumulation sometimes means simply the extraction of surplus from less privileged groups in society, rather than the construction of material wealth. The use of new financial instruments, and the push

for deregulation allowed certain groups to amass incredible riches. But history also teaches that those that play with the Promethean fire may very well end up burned. It is the task of those responsible for financial reform to make sure that the second lesson is also learned.

Notes

- ¹ The opinions expressed here are the authors' own and may not coincide with those of the institutions with which they are affiliated.
- ² See Ross (1987).
- ³ Bossaerts (2002: 41) provides a different definition: "beliefs are correct and can be estimated from empirical frequencies (i.e., that returns and consumption are stationary) is known in the finance literature as *the efficient market hypothesis* (EMH)".
- ⁴ See Fama (1970: 384).
- ⁵ See Ross (1987: 323).
- ⁶ The strong, semi-strong and weak efficiency hypotheses emphasize the 'informational property.' Fama's earlier definitions emphasize other properties. His January 1965 definition ("an 'efficient market' for securities, that is, a market where, given the available information, actual prices at every point represent very good estimates of intrinsic values") highlights the Martingale property of asset prices. His September-October 1965 definition emphasizes the competition properties: "An 'efficient market' is defined as a market where there are a large number of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants". His 1969 definition underscores the adjustment of "the market to new information".
- ⁷ Samuelson (1965) was the first to provide formal proof that in well-informed and competitive markets prices behave randomly.
- ⁸ The concavity of utility functions means that the gain of utility from consuming an additional unit of one commodity bundle (say, of X_1) is less than the utility loss from giving up an additional unit of the other commodity (say, of X_2). The assumption of risk aversion can be derived from the convexity of indifference curves by reasoning as follows. The convexity of indifference curves implies that under the simple assumption of a one period and two-commodity bundle world (X_1 and X_2) with no uncertainty, maximization of utility requires that a consumer strictly prefers a solution consisting of a combination of both than a corner solution (all of X_1 and no X_2 , or all of X_2 and no X_1). When the time horizon is expanded to introduce many periods (an intertemporal world) the consumer will smooth out his consumption over time, and prefer a smooth to an erratic time consumption path.

Following the logic of the example provided here, if in addition to intertemporality, uncertainty is introduced, the consumer must choose between two commodity bundles (X_1 and X_2) contingent upon two states of nature (S_1 and S_2). Maximization of utility requires that the consumer strictly prefer a certain commodity bundle (of X_1 and X_2) prospect in either state (S_1 , S_2) than an uncertain commodity bundle prospect with equal expected value (Silberberg, 1980).

The equivalency between concave utility functions and convex indifference curves can be formally stated as follows. Let an indifference curve I_0 be such that the level of utility throughout the curve is constant,

$$(2) U(X_1, X_2, p_{x1}, p_{x2}) = K,$$

where X_1 and X_2 are two normal state contingent commodity bundles. That is, they represent commodity bundles that are consumed only if a given state of nature is realized. p_{x1} and p_{x2} , denote the respective probabilities for the realization of the two states of nature S_1 and S_2 respectively.

K represents a level of constant utility, and U is a well behaved utility function. Total differentiation of (2) yields,

$$(3) p_{x1} \frac{\partial U}{\partial X_1} dX_1 + p_{x2} \frac{\partial U}{\partial X_2} dX_2 = 0 \Leftrightarrow \frac{dX_1}{dX_2} = - \frac{p_{x1} \frac{\partial U}{\partial X_1}}{p_{x2} \frac{\partial U}{\partial X_2}}$$

Taking the second derivative of $\frac{dX_1}{dX_2}$,

$$(4) \frac{d^2 X_1}{dX_2^2} = - \frac{(p_{x1} \frac{\partial U}{\partial X_1^2})(p_{x2} \frac{\partial U}{\partial X_2})}{(p_{x2} \frac{\partial U}{\partial X_2})^2} = - \frac{(p_{x1} \frac{\partial U^2}{\partial X_1^2})}{p_{x2} \frac{\partial U}{\partial X_2}}$$

The second derivative is positive if and only if $\frac{\partial U^2}{\partial X_1^2} < 0$, that is if U is concave. From here then follows the equivalency between convex indifference curves and concave utility functions.

- ⁹ Other approaches include mainly multi-factor pricing models such as the Arbitrage Pricing Theory and the Fama French Model.
- ¹⁰ Markowitz (1952) was the first to analyse portfolio choice in terms of expected return (mathematical expectation) and risk (the standard deviation).
- ¹¹ See Hoover (1988: 107); Modigliani & Miller (1958: 268).
- ¹² Note that the fact that returns are assumed to be stationary is equivalent to the efficient market hypothesis. See footnote 2 above.
- ¹³ Ibid.
- ¹⁴ See Taleb (2007: 278-79).
- ¹⁵ For any arbitrary initial values for the bond, say B_0 , the equation for the change in the value of the bond has the following analytical solutions,

$$(7) B_t = B_0 e^{rt}; \text{ where } r \text{ is the known free risk interest rate (or rate of return).}$$

- ¹⁶ For any arbitrary initial values for the stock, say S , the equation for the change in the values of the stock has the following analytical solutions,

$$(8) S_t = S_0 e^{(\mu - \frac{\sigma^2}{2})t + \sigma z_t}; S_t \text{ is a log-normally distributed random variable.}$$

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or more precisely,

$$D = SN(d_1) - Ke^{rM} N(d_2)$$

and

$$d_1 = \frac{\ln \frac{S}{K} + (r + \sigma^2 / 2)M}{\frac{\sigma}{\sqrt{M}}} \text{ and } d_2 = d_1 - \sigma\sqrt{M}$$

¹⁸ While it was realized that the volatility of a stock is not constant (Black, 1990), it could always be estimated from historical data. Since the BMS assumed that the world was Gaussian, past volatility was always regarded as a reliable guide of future volatility.

¹⁹ See Fox (2009).

²⁰ See Rosett (n.d.).

²¹ See Steinbock (2005); Capital Flow Analysis (2009).

²² China and India are two illustrative examples. In China the enrolment in MBA programmes increased from 86 in 1990 (the year the first MBA programme was introduced) to 10,000 in 2004. India also registered an important growth in MBA programmes and enrollment. According to Global Study Magazine, there are currently over 900 MBA programmes in India.

²³ Quoted in MacKenzie and Millo (2003: 121); MacKenzie (2003: 854); MacKenzie (2005: 18).

²⁴ See Merton (1997: 87).

²⁵ Ibid., p. 89.

²⁶ See Jarrow (1999: 3).

²⁷ See Duffie (1998).

²⁸ See Taleb (2007: 277).

²⁹ Self-fulfilling expectations can give rise to rational bubbles, since the asset prices would move towards the expected ones with no change in fundamentals (Blanchard, 1979).

³⁰ See Mirowski (1984); De Goede (2001).

³¹ See Brown *et al.*, (1998).

³² It is in this sense that Lucas (1977) states: "Rational expectations...will most likely be useful in situations in which the probabilities of interest concern a fairly well defined recurrent event...in so far as business cycles can be viewed as repeated instances of essentially similar events, it will be reasonable to assume their expectations [agents] are rational." Most recently, when referring he wrote (2004): "the problem that the new theories, the theories embedded in general equilibrium dynamics of the sort that we know how to use pretty well now- there's a residue of things they don't let us think about. They don't let us think about the U.S. experience in the 1930s or about financial crises in Asian and Latin America, they don't let us think about Japan in the 1990s."

- ³³ See for example Black (1993), “The Holes in Black-Scholes”, and “How to Use the Holes in Black-Scholes”, where Black focuses on the ten holes (unrealistic assumptions) of the Black-Scholes model. Merton explains (Ibid.: 1997): “...the mathematical model was developed entirely in theory, with essentially no reference to empirical option-pricing data as motivation for its formulation.”
- ³⁴ See Shefrin (2000).
- ³⁵ See Qiu and Mahangaonkar (2009).
- ³⁶ See Bernstein (1998: 204).
- ³⁷ See Davidson (2008: 675).
- ³⁸ Ibid.
- ³⁹ This follows from multiplying \$4,700 by the average S&P volatility and dividing it by the square root of the number of trading days (252)
- ⁴⁰ These computations are originally from Jorion (2000: 13). He also states that LTCM’s managers believed that the situation at the time was a ‘100-year flood.’
- ⁴¹ See Colander *et al.*, (2009).
- ⁴² See Lawson (2009).

References

- ‘MBAs and Ethics’, Capital Flow Analysis (2010), available at <http://www.capital-flow-analysis.com/investment-essays/mba.html>.
- ‘The evolving MBA’, Global Study Magazine 4.3 (2009), available at <http://www.ashridge.org.uk>.
- Blanchard, O. (1979), ‘Speculative bubbles, crashes, and rational expectations’, *Economic Letters*, 3, pp. 387-89.
- Brown, S.J., W.N. Goetzmann and A. Kumar (1998), ‘The Dow Theory: William Peter Hamilton’s Track Record Reconsidered’, *The Journal of Finance*, Vol.53, No.4, pp.1311-33.
- Colander, D., H. Foellmer, A. Haas, A. Kirman, K. Joselius, B. Sloth, T. Lux (2009), ‘Mathematics, Methods, and Modern Economics’, *Real World Economics Review*, No. 50, pp. 118-21.
- De Goede, M. (2001), ‘Discourses of Scientific Finance and the Failure of Long-Term Capital Management’, *New Political Economy*, Vol.6, No.2, pp. 149-170.
- Fama, E.F. (1970), ‘Efficient Capital Markets: A Review of Theory and Empirical Work’, *The Journal of Finance*, Vol.25, No.2, pp. 383-417.
- Fama, E.F. and K. French (2003), ‘The Capital Asset Pricing Model: Theory and Evidence’, Working Paper No.550, Center for Research in Security Prices (CRSP), University of Chicago.
- Fama, E.F. (2007), ‘Interview with Eugene Fama’, available at <http://www.minneapolisfed.org/pubs/region/07-12/fama.cfm>.

- Fox, J. (2009), *The Myth of the Rational Market*, New York: Harper.
- Hirschman A.O. (1977), *The Passions and the Interests*, Princeton: Princeton University Press.
- Hoover, K.D. (1988), *The New Classical Macroeconomics*, Cambridge: Basil Blackwell.
- Jarrow, R.A. (1999), 'Speech in Honor of Robert C. Merton', 1999 Mathematical Finance Day Lifetime Achievement Award.
- Jevons, W.S. (1965), *The Theory of Political Economy*, New York: Kelley Publishers.
- Jorion, P. (2000), 'Risk Management Lessons from Long-Term Capital Management', *European Financial Management*, 6, pp. 277-300.
- Lawson, T. (2009), 'Contemporary Economics and the Crisis', *Real World Economics Review*, No. 50, pp. 122-31.
- Lucas, R.E. (1980), 'Methods and Problems in Business Cycle Theory', *Journal of Money, Credit and Banking*, 12, Part 2, pp. 696-715.
- MacKenzie, D. (2005), 'Is Economics Performative? Option Theory and the Construction of Derivatives Markets', Paper presented to the annual meeting of the History of Economics Society, Tacoma, WA, June 25, 2005.
- MacKenzie, D. (2003), 'An Equation and Its Worlds: Bricolage, Exemplars, Disunity and Performativity in Financial Economics', *Social Studies of Science*, Vol.33, No.6, pp. 831-868.
- MacKenzie, D. and Y. Millo (2003), 'Constructing a Market, Performing Theory: The Historical Sociology of Financial Derivatives Exchange', *The American Journal of Sociology*, Vol. 109, No.1, pp. 107-145.
- MacKinsey & Company (2009), 'Global Capital Markets: Entering a new era', MacKinsey Global Institute.
- MacKinsey & Company (2008), 'Mapping Global Capital Markets', Fourth Annual Report, MacKinsey Global Institute.
- McKinsey & Company (2006), 'Mapping Global Capital Markets', Second Annual Report, McKinsey Global Institute.
- Merton, R.C. (1997), 'Applications of Option-Pricing Theory: Twenty-Five Years Later', Nobel Lecture. Nobel Prize Press Release, 'The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1997, available at http://nobelprize.org/nobel_prizes/economics/laureates/1997/press.html.
- Robbins, L. (1940), *An Essay on the Nature and Significance of Economic Science*, London: Macmillan.
- Shiller, R.J. (1981), 'Do Stock Prices Move Too Much to be justified by Subsequent Changes in Dividends?' *American Economic Review*, American Economic Association, 71(3), pp. 421-36.
- Steinbock, D. (2005), 'U.S. Business Schools: Origins, Rankings, Prospects', Helsinki: Academy of Finland.
- Taleb, N.M. (2007), *The Black Swan: The Impact of the Highly Improbable*, New York: Random House.
- Walras, L. (1952), *Elements D'Economie Politique Pure*, Paris: R. Pichon et R. Durand-Auzias.