Chapter 27. Finance in Modern Economic Thought

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Introduction

This chapter analyzes the place of modern finance[1] in modern economic theories. Financial theory and economics are closely linked. Indeed, the integration of market analysis into economic theory in the 1960s was what enabled modern financial theory to emerge. While some works on what was to become modern financial theory had been produced out prior to the 1960s, they were marginal[2] and did not yet constitute either an academic or a scientific discipline; applied mathematics and empirical investigations into finance existed, but these were isolated contributions, and most of them did not have a solid theoretical underpinning[3].

In order to analyze the place of finance in economics, this chapter sets out to show how economics has influenced, and continues to influence, modern financial theory.

The chapter is structured as follows. The first part focuses on the theoretical foundations of modern financial theory. It analyzes the way modern probability theory and economics were linked together to create modern financial theory. The second part presents the key works of the dominant paradigm of financial economics, which was built during the 1960s and the 1970s. It shows how major concepts and hypotheses from economics were integrated into mathematical models. The third part looks at anomalies that have emerged since the end of the 1970s and are inconsistent with the dominant paradigm. It explains how financial economics has developed alternative theories – financial market microstructure and behavioural

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[1] Modern financial theory and financial economics are synonymous. We use the two terms interchangeably here.

[2] Examples are the works of Jules Regnault (1863), Louis Bachelier (1900), Vincenz Bronzin (1908), Alfred Cowles (1933, 1944), and Holbrook Working (1934, 1935).

[3] Let me specify that the absence of theory characterizes all existing works written between the 1930s and the 1960s. Cowles (1933), Working (1934) and Kendall (1953) were the first English and American authors to analyze the random character of stock prices, none of them put forward a theory to explain the phenomenon. Theoreticians pointed out the absence of theoretical explanations during the 1950s. This was particularly striking after the Koopmans-Vining debate in the late 1940s, which set the NBER against the Cowles Commission over the lack of theoretical explanations and the need to link measurement with theory (Jovanovic 2008).

finance – to resolve these anomalies. (However, as will be explained, these developments have not led to any significant modification of the dominant paradigm in financial economics, even if its foundations have been called into question.) The last part deals with two major approaches born outside financial economics – social studies of financial markets and econophysics – which are among the greatest challenges to the foundations of the dominant paradigm of financial economics today.

I. The birth of modern financial theory: the role of economics and modern probability theory

Modern financial theory was born in the early 1960s. Two scientific disciplines played a fundamental role in its emergence: modern probability theory and economics.

The role of modern probability theory

Modern financial theory is intimately bound up with modern probability theory, from which its emergence, main models and results are inseparable. So close are the links that, further to the publications of Harrison and Kreps (1979) and Harrison and Pliska (1981)[4], it could be suggested that economics has been dispossessed of financial theory, which has since resembled an application of modern probability theory (MacKenzie 2006, 140-1). Or, as posited by Davis and Etheridge, Harrison and Pliska's article (1981) "has turned 'financial economics' into 'mathematical finance' " (Davis*, et al.* 2006, 114).

Modern probability theory – i.e. probability for continuous quantities in continuous time – emerged in the 1930s (Von Plato 1994) out of a number of works aimed at renewing traditional probability theory. The development of the modern version of probability theory was directly based on measurement theory (Shafer*, et al.* 2001). The connection was made by Kolmogorov, who proposed the main founding concepts of this new branch of mathematics.

From these beginnings in the 1930s, modern probability theory developed and became increasingly influential. But it was not until after World War II that Kolmogorov's axioms became the dominant paradigm in this discipline (Shafer*, et al.* 2005, 54-5). It was also after World War II that the American probability school was born, led by Doob[5] and by Feller[6]. These two writers had a major influence on the construction of modern probability theory, particularly through their two main books

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[4] These two publications gave a rigorous mathematical framework to definitions, hypotheses and results that constitute the heart of modern financial theory.

[5] Doob is without question the American mathematician who has had the greatest influence on modern probability theory in the United States. On Doob, see Bingham (2005).

[6] William Feller immigrated to the United States in 1939. He was one of the first defenders of the axiomatization proposed by Kolmogorov (Shafer*, et al.* 2005). At the colloquium on mathematical probability held in Geneva in October 1937, Feller declared that Kolmogorov's well-known axiomatization was the point of departure for most modern theoretical research in probability (Shafer*, et al.* 2005, 57). Moreover, Feller's *An Introduction to Probability Theory and Its Application* was, like Doob's 1953 publications, one of the works that most strongly influenced modern probability theory in the United States.

published in the early 1950s[7] which proved, on the basis of the framework laid down by Kolmogorov, all results obtained prior to the 1950s, thereby enabling them to be accepted and integrated into the discipline's theoretical corpus. These 1950s works led to the creation of a stable corpus that was accessible to nonspecialists. From then on, the models and results of modern probability theory were used in the study of financial markets in a more systematic manner, in particular by scholars educated in economics.

The first step in this development was the dissemination of mathematical tools enabling the properties of random variables to be used and uncertainty reasoning to be developed. The first two writers to use tools that came out of modern probability theory to study financial markets were Harry Markowitz and A. D. Roy. In 1952 each published an article on the theory of portfolio choice theory[8]. Both used mathematical properties of random variables to build their model[9]. Their work was to re-prove a result that had long been known (and which was as old as the adage, "Don't put all your eggs in one basket") using a new mathematical language, that of modern probability theory. Their contribution, then, lay not in the result of portfolio diversification, but in the use of this new mathematical language.

From the 1960s on, a new stage was embarked upon: authors no longer limited themselves to proving past results using the mathematical formalisms of modern probability theory, but connected mathematical formalism with the main concepts of economics, particularly the concept of equilibrium, to create new theories.

The role of economics

The institutional birth of modern financial theory arose precisely from the integration of economics' analysis framework into the study of financial markets (Jovanovic 2008). This integration was the result of the formation in the early 1960s of a community of economists devoted to the analysis of financial markets.

Let us remember that until the 1960s, finance in the United States was taught mainly in business schools. The textbooks used were very practical and few of them touched on what became modern financial theory. The research work that formed the basis of modern financial theory was carried out by isolated writers who were trained in economics or were surrounded by economists, such as Working, Cowles, Kendal, Roy, Markowitz, etc. No university community devoted to the subject existed prior to the 1960s[10]. During the 1960s and 1970s, training in American business

[7] Doob "finally provided the definitive treatment of stochastic processes within the measure-theoretic framework, in his *Stochastic Processes* (1953)" (Shafer*, et al.* 2005, 60). Doob worked on martingale theory from 1940 to 1950. Knowledge of martingale theory was spread gradually during the 1950s, mostly through *Stochastic Processes* (Meyer 2009). This book "became the Bible of the new probability" (Meyer 2009, 3).
[8] For a retrospective on Markowitz, see Rubinstein (2002) and Markowitz (1999).
[9] The mathematical properties of random variables are that the expected value of a weighted sum is the weighted sum of the expected values, while the variance of a weighted sum is not the weighted sum of the variances (because we have to take covariance into account).
[10] The new research path was not accepted by economists until the 1960s. Milton Friedman's reaction to Harry Markowitz's defence of his PhD thesis gives a good illustration. Friedman declared: "It's not economics, it's not mathematics, it's not business administration", and Jacob Marschak, who

schools changed radically, becoming more "rigorous"[11]. They began to "academicize" themselves, recruiting increasing numbers of economics professors who taught in university economics departments, such as Miller (Fama 2008). Similarly, prior to offering their own doctoral programs, business schools recruited doctorands who had been trained in university economics departments.

The recruitment of economists interested in questions of finance unsettled teaching and research as hitherto practiced in business schools and inside the American Finance Association. The new recruits brought with them their analysis frameworks, methods, hypotheses and concepts, and also used the new mathematics that arose out of modern probability theory. These changes and their consequences were substantial enough for the American Finance Association to devote part of its annual meeting to them in two consecutive years, 1965 and 1966.

At the 1965 annual meeting of the American Finance Association an entire session was devoted to the necessity to rethink courses in finance curricula. Paul Wendt discussed the development of finance and explained:

> "As most of you are aware, a modern concept of technical market analysis is emerging which emphasizes the application of newer analytical techniques and computer technology to test traditional and new theories of stock price behaviour. I am prepared to accept the view that this is not only a promising research area, but that graduate business school students should be introduced to these emerging theories and techniques of analyzing security market behaviour" (Wendt 1966, 421-2).

At the 1966 annual meeting, the new president of the American Finance Association presented a paper on "The state of the finance field," in which he talked of the changes being brought about by "the creators of the New Finance [who] become impatient with the slowness with which traditional materials and teaching techniques move along" (Weston 1967, 539)[12]. Although these changes elicited many debates (Whitley 1986b, 1986a, MacKenzie 2006, Poitras*, et al.* 2007, Jovanovic 2008, Poitras*, et al.* 2010)[13], none succeeded in challenging the global movement.

The antecedents of these new actors were a determining factor in the institutionalization of modern financial theory. Their background in economics allowed them to add theoretical content to the empirical results that had been

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supervised Markowitz during his PhD added: "It's not literature" (Markowitz 2004). See also Rubinstein (2002). Another illustration is provided by the dissemination of the first works of financial economics, which only truly started to circulate from the 1960s onwards. For example, citations of Markowitz' 1952 study really only began in the mid-1960s, once the founding articles of the CAPM had appeared (Jovanovic*, et al.* 2010c).

[11] See Mackenzie (2006, 72-3), Whitley (1986b, 1986a), Fourcade and Khurana (2009), and Bernstein (1992).

[12] The same issues were raised in training sessions given by Financial Analysts Seminar, one of the leading professional organizations connected with financial markets (Kennedy 1966).

[13] David Durand, professor at MIT, used his prestigious academic position to question the rise of modern financial economics (Durand 1959, 1968). Mackenzie (2007) observes: '[w]hen in 1968 David Durand, a leading figure from the older form of the academic study of finance, inspected the mathematical models that were beginning to transform his field he commented that "The new finance men … have lost virtually all contact with terra firma".'

accumulated since the 1930s and to the mathematical formalisms that had arisen from modern probability theory. In other words, economics brought the theoretical content that had been missing. Here are two examples to illustrate this change: the efficient markets theory and the CAPM.

The efficient markets theory[14], which can be considered as the first theory built by financial economists, was initially referred to as the "random walk theory." This term stresses the importance of mathematical formalism in the way issues were tackled before the discipline was constituted. The theory was first formulated by Fama (1965) – we will return to it in the next section – who developed the idea that the random walk model would test two properties of competitive economic equilibrium: the absence of marginal profit and a security's equilibrium value. According to the efficient markets theory, if the model used by investors to evaluate the value of the security does not use all available information, it will be possible to make an arbitrage. Thus, in an efficient market, the equalization between the price and the equilibrium value means that all available information is included in the price. Consequently, it is not possible to use past information to predict future price changes: present and future prices are independent of past prices. For this reason, in an efficient market, stock price changes must be as random as the arrival of new information. In other words, according to this theory, the random walk model can simulate the dynamic evolution of equilibrium prices in a competitive market. In this way, the efficient markets theory made it possible to link the mathematical model of a stochastic process with one of the keystones of economics, the concept of economic equilibrium.

In 1970, Fama based the efficient markets theory on another mathematical concept that came from modern probability theory: the martingale model[15]. For Fama's purposes, the most important attraction of the martingale formalism was its explicit reference to a set of information[16]. As such, the martingale model could be used to test the implication of the efficient markets theory that, if all available information is used, the expected profit is nil. This idea led to the definition of an efficient market that is generally used nowadays: "a market in which prices always 'fully reflect' available information is called 'efficient' " (1970, 383).
Here again, the part played by economics in the mathematical definition of the martingale model underlines economics' key role in the creation of the structure of modern financial theory.

The second illustration of how economics brought theoretical content to mathematical formalisms is the capital asset pricing model (CAPM). In finance, the CAPM is used to determine a theoretically appropriate required rate of return for an asset, if the asset is to be added to an already well-diversified portfolio, given the asset's non-diversifiable risk. The model takes into account the asset's sensitivity to non-diversifiable risk (also known as systematic risk or market risk or beta), as well

[14] This theory is sometimes called a hypothesis. But from a methodological point of view, it is a fully-fledged theory, even if it is used as a hypothesis in some models.
[15] The martingale model had been introduced to model the random character of stock market prices by Samuelson (1965b) and Mandelbrot (1966).
[16] By definition, a martingale model, $E(P_{t+1}|\Phi_t) - P_t = 0$, Φ_t is a filter, that is, using the terminology of financial economics, a set of information that increases over time.

as the expected return of the market and the expected return of a theoretical risk-free asset. This model is used for pricing an individual security or a portfolio. It has become the cornerstone of modern finance (Fama*, et al.* 2004). The CAPM is also built using an approach familiar to economists for three reasons. First, some sort of maximizing behaviour on the part of participants in a market is assumed; second, the equilibrium conditions under which such markets will clear are investigated; third, markets are perfectly competitive. Consequently, the CAPM provided a standard financial theory for market equilibrium under uncertainty.

The imbrication of the mathematical formalisms that emerged from modern probability theory and economics concepts, theory in particular, was a crucial factor in the birth of financial economics. By linking financial facts with economic concepts, the efficient market theory enabled financial economics to become a proper subfield of economics and consequently a scientific field. As we will now see, the heart of the dominant paradigm was constructed during this period on the same model as the efficient markets theory and the CAPM.

II. The constitution of the dominant paradigm of financial economics during the 1960s and 1970s

The decade of the 1960s saw the creation of the dominant paradigm of financial economics[17]. Contributions were numerous and substantive. It should be noted that almost all those who contributed to the construction of this paradigm have been rewarded by The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel[18], a measure of this paradigm's importance in economics. Five individuals – Harry M. Markowitz, William F. Sharpe, Merton H. Miller, Robert C. Merton and Myron S. Scholes – have received this distinction for contributions solely in the realm of financial economics. Markowitz, Sharpe and Miller were joint winners in 1990, and Merton and Scholes received the award jointly in 1997[19]. In addition, four other Nobel prize winners – Paul A. Samuelson (1970), John R. Hicks (1972), Franco Modigliani (1985) and Daniel Kahneman (2002) – made significant contributions to financial economics but were awarded the prize for an overall impact that covers a wider range of the economic sciences.

The dominant paradigm is made up of four main theories: the efficient market theory, the CAPM[20], the mean-variance portfolio optimization model and option pricing model. I will now present these briefly.

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[17] This section is based on Poitras and Jovanovic (2010) and Jovanovic (2010). For a historical perspective, see also Bernstein (1992), MacKenzie (2006), Mehrling (2005), and Jovanovic and Schinckus (2010c).

[18] A notable exception is Eugene Fama. It was expected that he would receive the award in 2008, but the financial crisis worked against him.

[19] Although the contributions of Fischer Black (1938–1995) were explicitly recognized, he was not a named recipient because the prize cannot be awarded posthumously, and the award was given to Merton and Scholes.

[20] We might also add the arbitrage pricing theory. This theory was initiated by the economist Stephen Ross in 1976. It assumes that the expected return of a financial asset is influenced by various macro-economic factors or theoretical market indices.

As explained above, the efficient markets theory[21] considers that stock market prices fluctuate randomly because all information is fully reflected in the prices. Although detailed empirical observations about the random character of security prices stretch back to the 19th century (Jovanovic*, et al.* 2001, Poitras 2006), these notions were crystallized into the basis of the efficient markets theory during the 1960s. Working (1956) was the first author to suggest a theoretical explanation of the random character of stock market prices; he established an explicit link between the unpredictable arrival of information and the random character of stock market price changes. However, this paper made no link with economic equilibrium and, probably for this reason, it was not largely circulated. Instead it was Roberts (1959, 7), a professor at the University of Chicago, who first suggested a link between economic concepts and the random walk model by using the "arbitrage proof" argument that had been popularized by Modigliani and Miller (1958). Cowles (1960, 914-5) then made an important step by identifying a link between financial econometric results and economic equilibrium. Finally, two years later, Cootner (1962, 25) linked the random walk model, information, and economic equilibrium, and set out the idea of the efficient markets theory, although he did not use that expression. It was a University of Chicago scholar, Eugene Fama, who formulated the efficient markets theory, giving it its first theoretical account in his 1965 doctoral thesis. In 1970, Fama developed the connection between "security prices fully reflecting available information" and martingale behaviour for security prices, laying the foundation for a future connection between the equivalent martingale measure and absence of arbitrage in security prices. At the same time, Fama, Fisher, Jensen and Roll (1969) proposed a statistical methodology that was applicable to testing of the "semi-strong form" version of the efficient markets theory, solidifying the empirical case against the strongest pillar of the old finance – security analysis.

The efficient markets theory was a crucial building block for modern financial economics. If markets are efficient, then techniques for selecting individual securities will not generate abnormal returns. In such a world, the best strategy for a rational person seeking to maximize expected utility is to diversify optimally. Achieving the highest level of expected return for a given level of risk involves eliminating firm specific risk by combining securities into optimal portfolios. Building on Markowitz (1952, 1959), Treynor (1961), Sharpe (a PhD student of Markowitz's) (Sharpe 1963, 1964), Lintner (1965a, 1965b) and Mossin (1966) made key theoretical contributions to the development of the capital asset pricing model (CAPM) and the single factor model. A new definition of risk is provided. It is not the total variance of a security return that determines the expected return. Rather, only the systematic risk – that portion of total variance that cannot be diversified away – will be rewarded with expected return. An *ex ante* measure of systematic risk – the beta of a security – is proposed and the single factor model used to motivate *ex post* empirical estimation of this parameter. Leading figures of the modern financial economics network, such

[21] In fact, there are several definitions of this theory. The definition has changed depending on the emphasis placed on a given feature by each author. For instance, Fama *et al.* (1969) defined an efficient market as "a market that adjusts rapidly to new information"; Jensen (1978) considered that "a market is efficient with respect to information set θ_t if it is impossible to make economic profit by trading on the basis of information set θ_t"; according to Malkiel (1992) "the market is said to be efficient with respect to some information set […] if security prices would be unaffected by revealing that information to all participants. Moreover, efficiency with respect to an information set […] implies that it is impossible to make economic profits by trading on the basis of [that information set]".

as Miller, Scholes and Black, examined the inherent difficulties in determining empirical estimates and developed important techniques designed to provide such estimates. A collection that promoted these important contributions was the volume edited by Jensen (1972).

The combination of these three essential elements – the efficient markets theory, the Markowitz mean-variance portfolio optimization model and the CAPM – constitute the core elements of analytical progress on modern portfolio theory during the 1960s. Just as a decade of improvement and refinement of modern portfolio theory was about to commence, another kernel of insight contained in Cootner (1964) came to fruition with the appearance of Black and Scholes (1973)[22]. Though the influential Samuelson (1965a) was missing from the edited volume, Cootner (1964) did provide, along with other studies of option pricing, an English translation of Bachelier's 1900 thesis and a chapter by Case Sprenkle (1961) where the partial differential equation based solution procedure employed by Black and Scholes was initially presented (MacKenzie 2003, 2007). Black and Scholes (1973) marks the beginning of another scientific movement – concerned with contingent claims pricing – that was to be larger in practical impact and substantially deeper in analytical complexity. The Black-Scholes-Merton model is based on the creation of a replicating portfolio which, if the model is clearly specified and its hypotheses tested, holds out the possibility of locally eliminating risk in financial markets. From a theoretical point of view, this model allows for a particularly fruitful connection with the Arrow-Debreu general equilibrium model, giving it a degree of reality for the first time[23].

III. Challenges to the dominant paradigm of financial economics: diversification of theoretical approaches

Hardly had the theoretical framework of the dominant paradigm been laid down when a number of works seriously challenged its foundations. A first set of studies called into question the theoretical bases of the dominant paradigm. In 1976, LeRoy showed that Fama's (1970) demonstration of the efficient markets theory was tautological and not testable[24]. In 1977, the same criticism was levelled at the CAPM: Roll (1977) asserted that the CAPM is tautological and is hard to test empirically since stock indexes and other measures of the market are poor proxies for the CAPM variables. LeRoy (1973) and Lucas (1978) provided theoretical proofs that efficient markets and the martingale hypothesis are two distinct ideas: the martingale is neither necessary nor sufficient for an efficient market. Although this criticism does not strictly speaking call into question the efficiency of markets, it shows that the first objective of the efficient markets theory (the creation of a link between a

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[22] See Perry (2005) on Fisher Black, and MacKenzie (2006) for a sociology analysis of the influence of this model.
[23] The Black-Scholes-Merton model has been associated *ex post* with Arrow-Debreu general equilibrium. Arrow and Debreu (1954) and later Debreu (1959) were able to model an uncertain economy and show the existence of at least a competitive general equilibrium which moreover had the property of being Pareto optimal. This model thus "for the first time gave reality to chapter 7 of Gérard Debreu's book *Théorie de la valeur* […] in which he talks of complete markets, that is, markets in which any contingent asset is replicable by basic assets" (Géman 1997, 50).
[24] See also Zuckerman's chapter in this book (2011) about the realistic of this hypothesis.

mathematical model and the concept of economic equilibrium) had not been fully achieved. However, the criticism from Grossman (1976) and Grossman and Stiglitz (1976, 1980) was more serious: they demonstrated that because information involves costs, perfectly informational efficient markets are impossible. In addition, in his chapter, Zuckerman (2011) points out that efficient market theory is not performative although this theory is widely adopted[25]. His analysis underlines the particular place of this theory in financial economics, as Jovanovic (2010) explained it.

In parallel with these theoretical attacks, a number of empirical studies very soon contradicted the conclusions of the dominant paradigm. At a 1969 conference, Fischer Black, Michael Jensen and Myron Scholes presented data demonstrating that the CAPM does not appear to adequately explain the variation in stock returns; their results were published three years later (Black*, et al.* 1972). Similarly, Douglas (1969) showed that the CAPM did not provide a complete description of the structure of security returns. Similar studies were produced throughout the 1970s. These empirical studies gave birth to what is known as the "anomalies literature." While this literature became important and well organized since the 1980s, it emerged during the 1970s. During the 1970s, the number of these anomalies and their significance for the dominant paradigm were so great that as early as 1978 a special issue of the *Journal of Financial Economics* was devoted to them.

Here is a quick summary of four of these anomalies[26].

The January Effect and the Week-End Effect
Keim (1983) and Reinganum (1983) showed that much of the abnormal return to small firms occurs during the first two weeks in January. This anomaly became known as the "turn-of-the-year effect." French (1980) observed another calendar anomaly. He noted that the average return to the Standard and Poor's (S&P) composite portfolio was reliably negative over weekends in the period 1953–1977.

The Winner's Curse
The winner's curse points out a tendency for the winning bid in an auction setting to exceed the intrinsic value of the item purchased. This suggests that investors are not rational enough to be aware of the true value of some assets (Thaler 1994).

Stock Price Volatility
Shiller (1981b, 1981a) published a study of the American market demonstrating that the volatility of stock market prices was greater than expected according to the standard framework.

The Size Effect
Banz (1981) and Reinganum (1981) showed that between 1936 and 1975 small-capitalization firms on the New York Stock Exchange (NYSE) earned average returns higher than CAPM predictions.

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[25] See also Boyer, Jovanovic and Schinckus (2011).
[26] Schwert (2003) provides a fairly exhaustive review of anomalies.

The anomalies attracted greater attention that theoretical criticism. Doubtless this was because, as Frankfurter and McGoun (2002) explained, anomalies were not initially perceived as challenges to the dominant paradigm; on the contrary, they were part of the paradigm. Nevertheless, this accumulation of divergences between empirical data and theoretical hypotheses set out by the dominant approach led to a theoretical diversification (Schinckus 2008, 2009a).

In the 1980s there emerged two alternative theoretical approaches that took as their starting point a questioning of these anomalies and of the main hypotheses of the dominant framework. These two approaches were behavioural finance and financial market microstructure. Both directly called upon the informational efficiency theory which, as we have seen, was a crucial element in the birth of modern financial theory.

Financial market microstructure

Although the theory of financial market microstructure has been developing since the 1980s[27], the first works appeared closer to 1970 with an article by Demsetz (1968) which looked at how to match up buyers and sellers to find a price when orders do not arrive synchronously. In 1971, Jack Treynor, editor in chief of the *Financial Analysts Journal* from 1969 to 1981, published a short article under the pseudonym of Walter Bagehot, "The Only Game in Town," in which he analyzed the consequences when traders have different motivations for trading. Maureen O'Hara, one of the leading lights of this theoretical trend, defined market microstructure as "the study of the process and outcomes of exchanging assets under a specific set of rules" (1995). Financial market microstructure focuses on how specific trading mechanisms and how strategic comportments affect the price formation process. This field deals with issues of market structure and design, price formation and price discovery, transaction and timing cost, information and disclosure, and market maker and investor behaviour.

Like the dominant paradigm of financial economics, financial market microstructure takes its theoretical foundation and its method from economics, new microeconomics in particular. Some of its hypotheses, however, are completely opposed to the dominant paradigm in financial economics. Likewise, the mathematical formalisms it uses are different from those of the dominant paradigm.

As regards mathematical formalisms, this theory largely uses the same mathematics as the new microeconomics (it uses asymmetric information) and chiefly employs a Bayesian probability approach. On this point it differs from the mathematical models traditionally used by the dominant paradigm, which mainly employ a frequentist probability approach.

As regards theoretical hypotheses, a central idea in the theory of market microstructure is that asset prices do not fully reflect all available information even if all participants are rational. Indeed, information may be unequally distributed

[27] The term "market microstructure" was coined by Mark Garman (1976), who studied order flux dynamics (the dealer must set a price so as to not run out of stock or cash). For a presentation of the discipline, see O'Hara (1995), Madhavan (2000) and Biais *et al.* (2005).

between, and differently interpreted by, market participants. This hypothesis stands in total contradiction to the efficient markets hypothesis defended by the dominant paradigm. The first generation of market microstructure literature has shown that trades have both a transitory and a permanent impact on prices (Biais *et al.* (2005)). For instance, Copeland and Galai (1983) showed that a dealer who cannot distinguish between informed and uninformed investors will always set a positive spread to compensate for the expected loss that he will incur if there is a positive probability of some investors being informed. Kyle (1985) suggests that informed dealers can develop strategic behaviour to profit from their information by concealing their orders among those of non-informed dealers. While informed dealers thus maximize their own profits on the basis of the information they hold, their behaviour restricts the dissemination of the information. O'Hara (2003) presents another example of results that contradict the dominant paradigm. In this article, she shows that, if information is asymmetrically distributed, and if those who do not have information know that others know more, contrary to the suggestions of the CAPM, we will not get an equilibrium where everyone holds the market portfolio.

Behavioural finance

The second alternative approach is behavioural finance.

In 1985 Werner F. M. De Bondt and Richard Thaler published "Does the stock market overreact?", effectively marking the start of what has become known as behavioural finance. Behavioural finance studies the influence of psychology on the behaviour of financial practitioners and the subsequent effect on markets[28]. Its theoretical framework is drawn mainly from behavioural economics.

Behavioural economics uses social, cognitive and emotional factors to understand the economic decisions of economic agents performing economic functions, and their effects on market prices and resource allocation. It is primarily concerned with the bounds of rationality of economic agents. The first important paper came from Kahneman[29] and Tversky (1979), who used cognitive psychology to explain various divergences of economic decision making from neo-classical theory.

There exists as yet no unified theory of behavioural finance[30]. According to Schinckus (2009b), however, it is possible to characterize this new school of thought on the basis of three hypotheses common to all the literature:

- The existence of behavioural biases affecting investor behaviour. This is a fundamental hypothesis that arises directly out of observations conducted in laboratories by cognitive psychologists. These behavioural biases are thought to be the main cause of differences between the observed behaviour of agents and the rational behaviour on which standard financial economics is based.

[28] See Schinckus (2009b, 2009a) for a presentation of this school and its positioning vis-à-vis the dominant paradigm.
[29] In 2002 Daniel Kahneman received The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel for his work on the integration of psychology with economics.
[30] Note that Shefrin (2002) made a first attempt to unify the theory.

- The existence of bias in investors' perception of the environment that affects their decisions. Behavioural finance thus presumes that the environment is opaque to individuals. This hypothesis comes from observations conducted in the laboratory and diverges from the dominant paradigm, which presumes that the context is completely transparent to investors' perceptions.

- The existence of systematic errors in the processing of information by individuals, which affects the market's informational efficiency. The markets are therefore presumed to be informationally inefficient. This hypothesis is the cause of the first two hypotheses.

Like those of financial market microstructure, the hypotheses of behavioural finance are opposed to those of the dominant paradigm. In addition, these two alternative schools agree on one major point: although they oppose the dominant paradigm, both draw their theoretical origins from economics. Through both these schools we see the importance of economics in the development of modern financial theory, which demonstrates the difficulty of reducing modern financial theory to a simple "mathematical finance."

In parallel with this theoretical diversification founded on economics, certain foundations of the dominant paradigm of financial economics are today being questioned by two new research fields outside of economics.

IV. Financial economics challenged by disciplines outside of economics: social studies of financial markets and econophysics

As we have explained, so-called "modern" financial theory is intrinsically linked with economics. Not only did economics provide the theoretical content necessary for the emergence of the dominant paradigm, but it also enabled the development of the two main alternative approaches, behavioural finance and financial market microstructure. But although economics has given theoretical content to modern financial theory, certain fundamentals of the dominant paradigm are today being challenged by two new research fields from outside economics. Two major approaches born outside financial economics emerged since the 1990s: social studies of financial markets and econophysics. Both challenge the foundations of the dominant paradigm of financial economics. These two theoretical trends are likely to influence the hypotheses of financial economics in the coming years.

Social studies of financial markets

Social studies of finance started to emerge in the 1990s. This multidisciplinary field, which I will not cover here (it is dealt with elsewhere in this volume), results from the application to financial markets of social-science disciplines such as sociology, anthropology, and social studies of science. The sociology of financial markets approaches financial markets from a sociological perspective (Cardon*, et al.* 2000, Knorr-Cetina*, et al.* 2005, MacKenzie 2006, Preda 2009). It seeks to provide an adequate sociological conceptualization of financial markets, and examines who the actors within them are, how they operate, within which networks, and how these networks are structured. One of the main concepts advanced by this field is the idea of performativity. According to MacKenzie (2006) and MacKenzie, Muniesa, and Siu (2007), financial models have performativity; they do not just describe markets, they transform them.

Econophysics

The second main approach that was born outside financial economics is econophysics[31]. Very broadly speaking, econophysics refers to the extension of physics to the study of problems generally considered as falling within the sphere of economics[32]. Financial economics, and more generally finance, are also subject to the influence of physics. One of the first authors to bring physics closer to the financial domain was Jules Regnault in the second half of the 19th century[33]. In the 20th century, a number of physics concepts played a part in the development of modern financial theory. But as McCauley points out (2004), in spite of these theoretical and historical links between physics and finance, econophysics represents a fundamentally new approach. Its practitioners are not economists taking their inspiration from the work of physicists to develop their discipline, as has been seen repeatedly in the history of economics. This time, it is physicists that are going beyond the boundaries of their discipline, using their methods to study various problems thrown up by social sciences. Econophysicists do not contend that they are attempting to integrate physics concepts into financial economics as it exists today, but rather that they are seeking to ignore, even to deny this discipline in an endeavour to replace the theoretical framework that currently dominates it with a new framework derived directly from statistical physics[34].

This movement was initiated in the 1970s, when certain physicists began publishing articles devoted to study of social phenomena, such as the formation of social groups (Weidlich 1971) or social mimetism (Callen*, et al.* 1974)[35]. The next decade confirmed this new theoretical trend (labelled *sociophysics*[36]), as the number of physicists publishing papers devoted to the explanation of social phenomena and the number of themes analyzed continued to increase, examples being industrial strikes (Galam*, et al.* 1982), democratic structures (Galam 1986), and elections (Galam 2004, Ferreira*, et al.* 2008).

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[31] On the emergence and analysis of econophysics, see Gingras and Schinckus (2012) and Jovanovic and Schinckus (2010a, 2010c).
[32] The influence of physics on economics is nothing new. A number of writers have studied the "physical attraction" (Le Gall 2002, 5) exerted by economics on hard sciences: Mirowski (1989) extensively highlighted contributions of physics to the development of marginalist economics and mathematical economics. Ingrao and Israel (1990) drew renewed attention to the influences of mechanics in the conceptualization of equilibrium in economics. Ménard (1981), Schabas (1990) and Maas (2005) also highlighted the role of physics in the economic works of Cournot and those of Jevons.
[33] See Jovanovic (2000) and Jovanovic and Le Gall (2001) on this subject.
[34] This explicit desire for methodological rupture contains the Kuhnian idea of the need for theoretical discontinuity in order to develop a new paradigm.
[35] Regarding the emergence and history of sociophysics, see Galam (2004).
[36] This term was proposed by Serge Galam in a 1982 article.

In the 1990s physicists[37] turned their attention to economics, and particularly financial economics, giving rise to econophysics. Although the movement's official birth announcement came in a 1996 article by Stanley *et al*. (1996),[38] econophysics was at that time still a young, ill-defined current. Mantegna and Stanley (1999, 2) defined econophysics as "a quantitative approach using ideas, models, conceptual and computational methods of statistical physics". Research conducted in this field mainly concerns the study of financial phenomena, marginalizing other themes analyzed by economics[39].

Econophysics has two main strengths that allow it to challenge the dominant paradigm of financial economics: it explains empirical facts that are not explained by the dominant paradigm in today's financial economics; and it uses a mathematical framework that represents a continuation of the models used by financial economists, but is more general.

Believing that financial market prices change more frequently and in a more orderly manner than presumed by the Gaussian model on which financial economics is based, econophysicists use Lévy distributions to describe financial data. Such distributions better describe the statistical distributions observed on financial markets[40]. This approach allows them to integrate a number of stylized facts such as "fat tails"[41], "volatility persistence"[42] and "volatility clustering"[43] that the traditional approach cannot explain (Jovanovic*, et al.* 2010a).

Econophysics' second strength lies in the use of mathematical models that generalize those used in financial economics. The main mathematical tools used by econophysicists are stable Lévy processes, which provide a more general mathematical framework, making Gaussian or Poisson processes particular cases. This use of Lévy processes, then, allows econophysics to provide a more general theoretical framework than that of financial economics, which uses Gaussian distribution.

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[37] The influence of physics on the study of financial markets is not new, as witnessed by the work of Bachelier (1900) and Black and Scholes (1973). Nevertheless, we cannot yet refer to Black & Scholes' model as econophysics in the term's current meaning, since it was completely integrated into the dominant theoretical current of economics and finance (Kast 1991). Econophysics is not an "adapted import" of the methodology used in physics; rather, it is closer to a "methodological invasion." We return to this point in the next section.

[38] This article is also the origin of the term *econophysics*.

[39] Although the application of statistical physics to economic touches on a number of subjects, such as corporate revenue (Okuyama*, et al.* 1999), the emergence of money (Shinohara*, et al.* 2001) and global demand (Donangelo*, et al.* 2000), these fields are marginal to judge by the number of articles published by physicists on the subject of financial markets. It is no accident, then, that the characteristics of econophysics mentioned by Rickles (2007, 4) all relate to finance.

[40] On this point, we should remember that economists and financiers have long been interested in the leptokurtic character of price distributions (Louçã 2007, 219; Jovanovic*, et al.* 2010b).

[41] The distributions of financial returns are more leptokurtic (with heavy tails) and exhibit a larger number of extreme events than a Gaussian framework would generate.

[42] According to the theoretical framework used by the dominant paradigm, security prices have *no* memory. Technically, however, the volatility has a slowly decaying autocorrelation showing a dependency between stock market returns.

[43] In reality, we can observe several periods of large fluctuations and periods of small fluctuations. In other words, periods of intense fluctuations and low fluctuations tend to cluster together.

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