Efficient markets theory

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Abstract: The Efficient Market Hypothesis (EMH) was crucial for the creation of financial economics as a proper subfield of economics. What we know today as the EMH was formulated in the period from 1959 to 1976 to give a theoretical explanation to the random character of stock market prices, a feature that had been noted as early as 1863. But the main characteristic of the EMH lies in linking three features that originally existed independently of each other: 1) the mathematical model of stochastic process; 2) the concept of economic equilibrium; 3) the statistical results about the unpredictability of stock market prices. Although debate continues about the interpretation and characterization of the EMH, the link between these three features allowed the creation of financial economics.

Main text: Without any doubt, it can be said that the Efficient Market Hypothesis(EMH) was crucial for the creation of financial economics. By linking financial facts with economic concepts, this theory enabled financial economics to become a proper subfield of economics and consequently a scientific field. But this was not its original goal: EMH was initially created to give a theoretical explanation of the random character of stock market prices.

The historical roots of EMH trace back to the 19th century in the work of Regnault and Bachelier, but this work was isolated and not embedded in a scientific community interested in finance. More immediate roots were in the empirical work of Cowles, Working and Kendall from 1933 to 1959, which laid the foundation for the key works published in the period from 1959 (Roberts) to 1976 (Fama's reply to LeRoy). More than any other single contributor, it was Fama in his 1965 dissertation, building on the work of Roberts, Cowles, and Cootner, who put the EMH into intellectual play. And it has continued to be in play ever since, with varying interpretations and characterizations.

EMH's objectives and the first works in financial economics

EMH was created in the 1960s. Its initial formulation suggested that stock prices reflect all available information, and that, consequently, the actual price of a security is equal to its intrinsic value. In addition, because new information arrives randomly, stock prices fluctuate randomly.

The idea that stock prices fluctuate randomly was not new: in 1863, a French broker, Jules Regnault, had already suggested it. Regnault was the first author to put

forward this hypothesis, to validate it empirically, and to give it a theoretical interpretation. In 1900, Louis Bachelier, a French mathematician, used Regnault's hypothesis and framework to develop the first mathematical model of Brownian motion, and tested the model by using it to price futures and options. In retrospect, we can recognize that Bachelier's doctoral dissertation constitutes the first work in mathematical finance. Unfortunately for him, however, financial economics did not then exist as a scientific field, and there was no organized scientific community interested in his research. Consequently, both Regnault and Bachelier were ignored by economists until the 1960s.

Although these early authors did suggest modeling stock prices as a stochastic process, they did not formulate the EMH as it is known today. EMH was genuinely born in linking three features that originally existed independently of each other: 1) the mathematical model of a stochastic process (random walk, Brownian motion, or martingale); 2) the concept of economic equilibrium; 3) statistical results about the unpredictability of stock market prices. EMH's creation only took place between 1959 and 1976, when a large number of economists became familiar with these three features. Between Regnault's and Bachelier's time and the development of EMH, there were no theoretical preoccupations per se about the random character of stock prices, and research was only empirical.

Empirical research between 1933 and 1959

Between 1933 and the end of the 1950s, only three authors dealt with the random character of stock market prices: Cowles (1933, 1944), Working (1934, 1949) and

Kendall (1953). They compared stock price fluctuations with random simulations and found similarities. One point must be underlined: these works were strictly statistical, and no theory explained these empirical results.

The situation changed at the end of the 1950s and during the 1960s due to three particular events. First, the Koopmans-Vining controversy at the end of 1940s led to a decline of descriptive approaches and to the increased use of modeling based on theoretical foundations. Second, modern probability theory, and consequently also the theory of stochastic processes, became usable for non-mathematicians. Significantly, economists were attracted to the new formalisms by some features that were already familiar consequences of economic equilibrium. Most important, the zero expected profit when prices follow a Brownian motion reminded economists of the zero marginal profit in the equilibrium of a perfectly competitive market. Third, research on the stock market became more and more popular amongst scholars: groups of researchers and seminars in financial economics became organized; scientific journals such as the *Journal of Financial and Quantitative Analysis* were created and a community of scholars was born. This context raised awareness about the need for theoretical investigations, and these investigations in turn allowed the creation of the EMH.

Theoretical investigations during the 1960s

Financial economists did not speak immediately of EMH; they talked about “random walk theory”. Following his empirical results, Working (1956) was the first author to suggest a theoretical explanation; 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 diffused. Instead it was Roberts (1959), 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). Then, Cowles (1960) made an important step by identifying a link between financial econometric results and economic equilibrium. Finally, two years later, Cootner (1962) linked the random walk model, information, and economic equilibrium, and exposed the idea of EMH, although he did not use that expression.

Cootner (1962) had the essential idea of EMH, but he did not make the crucial empirical link because he considered that real world stock price variations were not purely random. This point of view was defended by economists from MIT (as Samuelson) and Stanford University (as Working). By contrast, economists from the University of Chicago claimed that real stock markets were perfect, and so were more inclined to characterize them as efficient. Thus it was a scholar from the University of Chicago, Eugene Fama, who formulated the EMH. In his 1965 Ph. D. thesis, he gave the first theoretical account of EMH. In that account, the key assumption is the existence of “sophisticated traders” who, due to their skills, make a better estimate of intrinsic valuation than other agents do by using all available information. Provided that such traders have access to sufficient financial resources, their activity of buying underpriced assets and selling overpriced assets will tend to make prices equal intrinsic values, and also to eliminate any expectation of profit from trading. Linking these consequences with the random walk model, Fama added that because information arrives randomly, stock prices have to fluctuate randomly. Fama thus offered the first

clear link between empirical results about stock price variations, the random walk model, and economic equilibrium. EMH was born.

Evolution of Fama's definition during the 1970s

Five years after his Ph.D. dissertation, Fama (1970) tried to offer a mathematical demonstration of the EMH. He simplified his first definition by making the implicit assumption of a representative agent. He also used another stochastic process: the martingale model, which had been introduced to model the random character of stock market prices by Samuelson (1965) and Mandelbrot (1966). The martingale model is less restrictive than the random walk model: the martingale model requires only independence of the conditional expectation of price changes whereas the random walk model requires also independence involving the higher conditional moments (i.e., variance, skewness, and kurtosis) of the probability distribution of price changes. For Fama's purposes, the most important attraction of the martingale formalism was its explicit reference to a set of information, Φ_t,

$$E(P_{t+1}|\Phi_t) - P_t = 0 \qquad (1).$$

As such, the martingale model could be used to test the implication of EMH that, if all available information is used, the expected profit is null. 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).

However, in 1976, LeRoy showed that Fama's demonstration is tautological and that his theory is not testable. Fama answered by changing his definition and admitted

that any test of the EMH is a test of both market efficiency and the model of equilibrium used by investors.

The proliferation of definitions since the 1970s

This proved to be a fateful admission. In retrospect it is clear that the theoretical content of EMH consisted in its suggestion of a link between some mathematical model, some empirical results, and some concept of economic equilibrium. The precise linkage proposed by Fama was however only one of many possible linkages, as subsequent literature would demonstrate. Just so, LeRoy (1973) and Lucas (1978) provided theoretical proofs that efficient markets and the martingale hypothesis are two distinct ideas: martingale is neither necessary nor sufficient for an efficient market. In a similar way, Samuelson (1973), who gave a mathematical proof that prices may be permanently equal to the intrinsic value and fluctuate randomly, explained that it cannot be excluded that some agents make profits, contrary to the original definition of EMH. De Meyer and Saley (2003) show that stock market prices follow a martingale even if all available information is not contained in stock market prices.

This proliferation at the level of theory has been matched by proliferation at the level of empirical testing, as the definition of EMH has changed depending on the emphasis placed by each author on one particular feature. 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]". The situation is similar as regards to tests: the type of test used depends on the definition used by the authors. Moreover, some authors have used the weakness of the definitions to criticize the very relevance of efficient markets. For instance, Grossman and Stiglitz (1980) argued that because information is costly, prices cannot perfectly reflect all available information. Consequently, they considered that perfectly informationally efficient markets are impossible.

The history of EMH shows that the definition of this theory is plural, and the initial project of EMH (the creation of a link between a mathematical model, the concept of economic equilibrium, and statistical results about the unpredictability of stock market prices) has not been fully achieved. Moreover, this theory is not empirically refutable (since a test of the random character of stock prices does not imply a test on efficiency). Nevertheless, financial economists have considered EMH as one of the pillars of financial economics because it played a key role in the creation and history of financial economics by linking financial results with standard economics. This link is the main contribution of EMH.

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