The Efficient Market Hypothesis and Rational Expectations. How Did They Meet and Live (Happily?) Ever After

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Abstract

This article investigates the origins and early development of the association between the efficient market hypothesis and rational expectations. We argue that the two concepts were independently developed in the 1960s; they were then associated for the first time by Thomas Sargent "Rational Expectations and the Term Structure of Interest Rates" (1972a). We describe how the subsequent debate on the term structure (involving Sargent, Franco Modigliani, Robert Shiller, and Eugene Fama) and the contribution by Robert Lucas (1978) brought to a reformulation of the efficient market hypothesis as the outcome of rational expectations equilibrium models. By the 1980s, the association became a step-stone for both macroeconomics and finance.

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Introduction

The efficient market hypothesis and rational expectations are today benchmark concepts for mainstream approaches to, respectively, finance (or "financial economics") and macroeconomics. Moreover, most scholarship in each of these two fields *associates* the efficient market hypothesis and rational expectations, i.e. it claims that they are closely related (or even equivalent) equilibrium concepts.

Contemporary literature in finance usually attributes the efficient market hypothesis to Paul Samuelson (1965) and to Eugene Fama (1965, who was actually the first using the expression "efficient market"). The efficient market hypothesis is usually summarized as the idea that "prices of financial assets fully reflect all available information" (e.g. Lo 2008: 2)—although several other formulations and definitions exist (see e.g. Walter 2006; Vuillemey 2013). Rational expectations are attributed to John Muth (1961), although his idea achieved fame thanks to "new classical macroeconomics" developed by Robert Lucas and Thomas Sargent in the 1970s. Sargent, in his entry "Rational Expectations" for the *New Palgrave Dictionary of Economic*, defines rational expectations as "an equilibrium concept that attributes a common model … to nature and to all agents in the model" (Sargent 2008: 1). The key implication is that "the forecasts made by agents within the model are no worse than the forecasts that can be made by the economist who has the model" (Sargent 2008: 1).[2]

Today, rational expectations and the efficient market hypothesis are associated, insofar as it is argued that asset prices "reflecting fully all available information" are equivalent to prices reflecting the "best" or "optimal" forecast on the asset future return (or, in Sargent's words, the forecast from a "common model"). For instance, the very popular financial economics textbook by Frederic Mishkin's associates the two concepts as follows:[3] (i) rational expectations are expectations "identical to optimal forecast (the best guess of the future) using all available information" (Mishkin 2016: 192);[4] (ii) asset prices should reflect expectations on future returns (e.g., for stocks, the expected discounted sum of future dividends, Mishkin 2016: 190).[5] Therefore, market participants will converge towards an "equilibrium price" reflecting the optimal forecasting, since all prices reflecting non-optimal forecasts on returns (i.e. non-

[2] This echoes Muth (1961: 316)'s original definition of rational expectations as "[expectations that] are essentially the same as the predictors of the relevant economic theory"

[3] A similar line of reasoning can be found in other popular finance textbooks (e.g. Burton et al. 2010) and in some macroeconomics textbooks (e.g. Burda and Wyplosz 2013).

[4] This also echoes one of Muth (1961: 316)'s justification for his rational expectations assumption: "information is scarce, and the economic system generally does not waste it".

[5] This is also sometime called the "fundamental value" or "intrinsic value".

rational expectations) would lead to over-pricing or under-pricing of assets—i.e. the current price would imply higher or lower future return than that implied by "the best guess" (Mishkin 2016: 196-197). Market participants are assumed to act in order to avoid such unexploited profit opportunities (arbitrage).

The legitimacy of this association is also supported by claims about the common origins of the two concepts; that is, the idea that the two concepts were devised from the start as consistent, related ideas. Claims on their common origins are found in several self-produced historical narratives, i.e. historical accounts produced by practitioners in macroeconomics or in finance. Often, these narratives trace back the origins of the association to the 1960s. One narrative claims that, *thanks to* the efficient market hypothesis, rational expectations were "discovered" by Muth and then "brought into fashion" by new classical macroeconomics in the 1970s. An alternative narrative holds the reverse view: inspired by Muth (1961), the success of rational expectations in macroeconomics during the 1970s *led to* the development of the efficient market hypothesis in finance.

Both these narratives (and others) consist of incidental or anecdotal remarks, relying on sketchy historiographical evidence. However, historians of economics do not dispose of any alternative account on the origins and development of the association between rational expectations and the efficient market hypothesis. Although historians have recently produced a significant amount of scholarship about the post-war evolution either of macroeconomics or of finance, very few contributions have been investigating the relations between the two fields, and none addressed the origins of the association between their benchmark concepts.[6] The purpose of this paper is precisely to start filling this gap. Our investigation of the origins and early development of the association between rational expectations and the efficient market hypothesis should then been seen as one illustrative example of the emergence, during the 1970s, of stronger relationships between finance and macroeconomics.

Our investigation starts with an assessment of self-produced narratives about the origins of the association, based on historical literature and evidence (section 1). We conclude that the two concepts are more likely to be characterized as independent developments, stemming from distinct research programs. We then uncover the first instance of the association between the

[6] An early exception is Hoover (1988: chap. 5). Hoover argues that Fama (1980) has provided the influential basis for the extension of new classical macroeconomics to finance, money, and banking. Young (2014) and Mehrling (2005) also provide similar insights on the dialogue between new classical macroeconomics and financial economists: Fischer Black—one of the pioneers of option pricing model (Black and Scholes 1973)—for instance, played a key role in the development of the real business cycle (RBC) approach, through his comments on different drafts of Kydland and Prescott (1982) and Long and Plosser (1983).

two concepts (section 2). We argue that Sargent (1972a) was the first published contribution discussing explicitly the connection between rational expectations and the efficient market hypothesis and applying it to the analysis of the term structure of interest rates (i.e. the relation between short-term and long-term interest rates of bonds). Sargent's contribution, together with Franco Modigliani and Robert Shiller (1973)'s and Fama (1975)'s replies, reframed the (pre-existing) debate about the empirical testing of theories of term structure of interest rates. Moreover, we argue that this debate contributed to the redefinition of the efficient market hypothesis as the equilibrium outcome of rational expectations models—first by Fama (1975), then by Fama (1976a; 1976b), and finally by Lucas (1978). These theoretical refinements represented the concluding step of a long process (which had started in the 1950s; see Jovanovic 2008), aiming at anchoring the efficient market hypothesis (and finance) into an "equilibrium discipline" proper to the field of economics.

Section 3 illustrates how the association between rational expectations and the efficient market hypothesis rapidly gained traction in the mid-1970s. The association was stabilized and took its contemporary form, both in macroeconomics and in finance. Moreover, the use of rational expectations equilibrium models favoured further developments and discussions about the definition of efficient financial markets, particularly in finance. We scrutinize two representative examples of this development: Shiller ([1979] 1981a; [1980] 1981b) empirical test of the efficient market hypothesis, which paved the way to the literature in behavioral finance about "market valuation"; Sanford Grossman and Joseph Stiglitz (1980) theoretical model, which fostered the development of a literature on the informational structure of financial markets.

1. Self-produced Narratives and Historical Evidence

This section argues that is not trivial to identify the actual origins of the association between rational expectations and the efficient market hypothesis. We discuss some examples of self-produced narratives about the origins of the association, which are drawn from four types of contemporary (from the 2000s and 2010s) materials: (i) dictionaries (notably *The New Palgrave Dictionary of Economics*); (ii) textbooks in macroeconomics and in finance; (iii) literature reviews and surveys on the efficient market hypothesis;[7] (iv) personal memories (interviews or

[7] Literature reviews played a distinctive role in this field. From Fama (1970) onward, literature reviews were instrumental in consolidating concepts, in setting new orientations for the research program (e.g. Fama 1991), and in raising criticisms (e.g. Jensen 1978) and counterattacks (e.g. Malkiel 2003).

autobiographies). The materials selected here are illustrative of "stabilized" or "consensual" knowledge, which play a key role in structuring, showcasing and reproducing the state of a field.[8] From the analysis of these materials, we identify five distinct narratives about the origins of the association between rational expectations and the efficient market hypothesis. This section presents, in turn, these five narratives and provides a critical assessment based on historical literature. We point out that some claims about the origin of an association in the 1960s seems incompatible with (or at least very unlikely in light of) the available evidence.

1.1 Samuelson (1965) as a Precursor of Muth (1961)

In his account of Samuelson's contribution to finance, Robert Merton (2006) claims that Samuelson (1965)'s early formulation of the efficient market hypothesis could be seen as using (implicitly) rational expectations *à la* Muth.[9]

The historical literature on the history of rational expectations has already identified several potential "precursors" to Muth.[10] Keuzenkamp (1991) discusses Jan Tinbergen ([1932] 1933)'s use of expectations that would be "rational, i.e. consistent with the economic relationships".[11] Besides, Keuzenkamp refers to a wide set of authors addressing the issue of expectations and allegedly having come close to Muth's formulation: nevertheless, Keuzenkamp's list does not mention any financial economist (although Keuzenkamp refers loosely to the interest on expectations by "market analysts"). Young et al. (2004) also highlight several patterns of research on expectations in the 1950s, patterns that ultimately converged, notably, in a collective volume edited by Holt, Modigliani, Muth and Simon (1960). Young and co-authors briefly discuss also Samuelson (1957)'s model of speculation on perishable commodities, which featured expectations that "as in Muth … are the predictions of the model itself" (Young et al. 2004: 20). However, they are reluctant to consider this as entirely

[8] We follow here the approach taken by similar historiographical work on "self-produced" or "standard" or "canonical" narratives (see for instance, for finance, Jovanovic 2008, and, for macroeconomics, Duarte and Lima 2012; Sergi 2020).

[9] Moreover, Merton also argues that Samuelson had been disseminating the ideas of his 1965's article during the decade preceding its publication, through several talks, including one lecture at Carnegie (where Muth was based). Merton suggests then that this circulation is likely to have had an impact on rational expectations (Merton 2006: 14). However, Samuelson claimed that he had no influence on Muth (Letter to Bernstein, 01/02/1991. Correspondence with Peter Bernstein, Box 16, 1948-2009. Paul A. Samuelson Papers, 1933-2010 and Undated. David M. Rubenstein Rare Book and Manuscript Library, Duke University).

[10] Research on "precursors" of rational expectations is still ongoing. Recent scholarship points out for instance the hypothesis of "ideal expectations" made by Holbrook Working (1949; 1958)—see Berdel and Choi (2019).

[11] Young et al. (2004: chap. 4) argues against this interpretation, since they rather see Tinbergen as a precursor of the "implicit expectations" program set in motion by Edwin Mills (on this program, see Young and Darity 2001).

comparable with Muth's rational expectations, since, they argue, Samuelson rather relied on the (already existing) idea of "perfect foresight", i.e. a form of certainty equivalence (*ibid.*). Other authors are reluctant to identify any "precursors" to Muth: as suggested by Hoover and Young (2011: 19), although several economists "came close" to this concept before 1961, nevertheless they "never quite capture Muth's definition".[12]

Even if we take Merton's claim less literally and we consider the literature on the efficient market hypothesis beyond Samuelson, we still face a similar problem. So far, available historical evidence has not highlighted any connection between finance and Muth's own work. Young et al. (2004: chap. 2-3) provided a rich scrutiny of all the research programs connected with Muth.[13] Nevertheless, an important finding leaves the door open to the *possibility* of a connection: indeed, besides Muth and his colleagues at Carnegie Graduate School of Industrial Administration (GSIA), the University of Chicago (through the "Public Finance and Money" workshop) was also actively involved with this research network on expectations (Young et al.: chap. 3). Therefore, it is possible that financial economists located in Chicago (e.g. Harry Roberts, Fama) were discussing—or at least were aware—of the ongoing developments on expectations, including Muth's work on rational expectations. Symmetrically, it is possible that Muth was aware, in the 1960s, of the ongoing work in finance about the efficient market hypothesis. Nevertheless, this remains a conjecture, which is contradicted by other self-narratives (see section 1.4).

1.2. The Efficient Market Hypothesis and its Influence on Rational Expectations Macroeconomics

A second narrative claims that the 1960s literature on the efficient market hypothesis inspired rational expectations (or, new classical) macroeconomics. Stephen Ross, in his "Finance" entry to *The New Palgrave Dictionary of Economics*, argues that rational expectations models "consistent with certain versions of the efficient market theories" constituted a very late development compared to Fama (1965) and other early works on the efficient market hypothesis (Ross 2008: 6). These later developments were "parallel" to the "neoclassical rational expectations view of macroeconomics", and

[12] Lucas also strongly objects against the idea of "precursors", arguing that "we don't want to go back to all the people who used the words "rational" and "expectations" … no one had anything like [Muth] before" (Hoover and Young 2011: 15).

[13] This includes obviously research at Carnegie (notably Herbert Simon's work on bounded rationality), but also other formal and informal research program such as the "Illinois project" led by Modigliani, or the "implicit expectations" program led by Mills.

This is no accident since the rational expectations school of macroeconomics was clearly influenced by the intuition of efficiency in finance. The original insight that prices reflect the available information lies at the heart of rational expectations macroeconomics (Ross 2008: 6)

Ross' claim depicts a plausible chronology: since the efficient market hypothesis was already a well-established theory by the end of the 1960s, it could have inspired new classical macroeconomics, as it started gaining momentum in the early 1970s. However, macroeconomists usually do not acknowledge any "inspiration" coming from finance. For instance, *New Palgrave* entries (e.g. Sargent 2008; Fischer 2008) and textbook (e.g. Blanchard 2016) do not mention any connection with finance. If there was an influence or inspiration, it is either neglected or forgotten: not only by macroeconomists but also by historical scholarship investigating the methodological and theoretical turn in macroeconomics set in motion by Lucas and Sargent (e.g. Hoover 1988; Duarte and Lima 2012; De Vroey 2016). Even the contributions scrutinizing more closely the originating sources of Lucas and co-authors' work (see e.g. Louça 2004; da Silva 2017) do not uncover any influence of the efficient market hypothesis.[14]

In this context, Ross' narrative (and, to a lesser extent, Merton's) seems rather aiming at suggesting that 1960s finance was not a marginal field, but a driving force for the development of economics, capable of influencing the discipline as a whole as well as other subfields, such as macroeconomics. The idea is rather explicit in one of Ross' early surveys on finance, where he argues that "economics, in general will greatly benefit from the tools and data developed in finance". For instance, "finance gave economics its penchant for rational expectations", since "early work on efficient markets, [which] was the impetus if not the cornerstone of the neoclassical, rational expectations school of macroeconomics" (Ross 1987: 34).

1.3 Muth as the "Father" of both the Efficient Market Hypothesis and Rational Expectations Macroeconomics

[14] Similarly, Sent (1998) reports "ten stories" (or, "hypothesis") that she encountered in her investigation about the raise of rational expectations in macroeconomics: again, none of these is connected to the efficient market hypothesis or to finance.

A third widespread narrative tells the reverse story compared to Ross and Merton's. Indeed, it identifies Muth as the common source of parallel developments in finance and macroeconomics.

Mishkin (2016: 195) distinguishes three historical lines of work in the 1960s and 1970s: the "theory of rational expectations" (i.e. Muth 1961); "monetary economics" (i.e. Lucas and Sargent's new classical macroeconomics); and "financial economists" (i.e. Fama). Mishkin places Muth (1961) at the top of the family tree, while the two other strains followed, as two "parallel developments" resulting from Muth's work: "While monetary economists were developing the theory of rational expectations, financial economists were developing a parallel theory of expectations formation for financial markets." (Mishkin 2016: 195)[15] Furthermore he adds as a footnote:

> *The development of the efficient market hypothesis was not wholly independent of the development of the rational expectations theory in that financial economists were aware of Muth's work (Mishkin 2016: 195)*

The claim that financial economists working on the efficient market hypothesis were "aware of Muth's work" does not rely on any obvious evidence or source.[16] Notably, self-produced narratives arising from autobiographical accounts are contrasted on this point. While Lucas and Fama are skeptical of this connection (*cf. infra*, 1.4), Richard Roll claims that he was already aware of Muth work while writing his dissertation (1965-1968, under Fama's supervision), "because his fellow students and professors at Chicago had used it as one element in constituting their ideas about market efficiency" (Sent 1998: chap. 1, fn. 7). However, historians have not uncovered any concrete element (citations, references or archives) supporting this connection, although it could be a possibility. Roll (pers. comm., February 20, 2020) convincingly argues that financial economists at University of Chicago were not citing Muth's theoretical ideas because, in the 1960s, they were rather concerned with empirical testing of the efficient market hypothesis. This hypothesis is consistent with the current historiography about the reception of Muth's ideas. According to Young et al. (2004), Muth's

[15] The structure of this chapter of Mishkin's textbook follows this lineage: rational expectations are discussed first, then the efficient market hypothesis is introduced as "just an application of rational expectations to financial markets" (*ibid*. 195). Other textbooks follow the same presentation: see e.g. Howells and Bain ("The efficient market hypothesis is just one application of the 'theory of rational expectations' first set out by John Muth"; Howells and Bain 2013: 573), Burton et al. (2010: 146), or Blake (2001: 398).

[16] Jovanovic (2009, 70) mentions for instance that Fama (1970) had been influenced by Muth (1961), although no clear explanation is provided.

works was not obscure (since it was part of a wide network of research on expectations) and it was presented several times, including at the 1959 annual meeting of the Econometric Society and in Chicago (Young et al 2004: chap. 4-5). However, despite this awareness about Muth's work, the idea of rational expectations was far from being fully appreciated as a breakthrough.[17] All along the 1960s, rational expectations were thus "a solution in search of a problem" (Yong et al 2004: xi): applications of Muth's idea remained scarce, until new classical macroeconomics somehow vindicated Muth by making of him a "father figure".

1.4 Rational Expectations and the Efficient Market Hypothesis as Independent Discoveries

Whilst the previous three narratives are built on the claim that one concept "influenced" or "inspired" the other in the 1960s, another narrative, mostly found in autobiographical accounts, argues that no connection between the two ideas was established during the 1960s, and that rational expectations and the efficient market hypothesis arose as "independent discoveries". This latter account is consistent with the absence (so far) of available historical evidence (citation, mention, …) on a connection between ideas, authors, or research programs in the 1960s.

Hoover and Young (2011: 22) directly asked Lucas: "When rational expectations and the efficient market hypothesis were first connected?" Lucas's answer rather relied on Merton Miller's opinion that the two concepts were not connected at all in the 1960s:

> *Merton Miller was on both thesis committees. He was on Jack's [Muth] committee at Carnegie Tech; and when he moved to Chicago, he was in Gene Fama's committee. So I asked him that question once, and said "we didn't see it". He knew both theses, but he didn't see that they were saying very similar things. (Lucas in Hoover and Young 2011: 22)*[18]

The later encounter between the two concepts (and the two communities) took place at Carnegie GSIA at the very end of the 1960s. Lucas, in his Nobel autobiography, recalls that "Dick Roll, a student of Eugene Fama's at Chicago, brought the ideas of efficient market theory to GSIA" (Lucas 1996). Roll confirms this idea in his own recollection about his arrival at Carnegie in

[17] Several explanations are provided for what is, in retrospect, a surprising neglect or lack of reaction: see Young et al. (2004: chap. 4-5), Sent (2002) but also Lucas's own account (in Hoover and Young 2011: 16).

[18] Fama confirmed Lucas's narrative (pers. comm., February 14, 2020), while Roll remains sceptical (pers. comm., February 20, 2020).

1968 (Roll, pers. comm., February 20, 2020; see also Sent 1998: chap. 1, fn. 7). Sargent mentioned as well that he became aware of the work of Fama and Mandelbrot, when he met Roll at the end of the 1960 (Sargent in Sent 1998: 167; see also Sargent 1996: 17-18).

1.5 Rational Expectations Macroeconomics and its Influence on the Efficient Market Hypothesis

A fifth set of narratives argues that rational expectations in macroeconomics have been responsible for the blossom of the efficient market hypothesis. Robert Hall (1996: 42) claims that Lucas (1978)'s asset pricing model "gave structural content to the relationships alluded to in the finance literature". More specifically, it is Lucas's model based on rational expectations that reframed the efficient market hypothesis in general equilibrium terms:

> *[Lucas] integrated ideas from economics and finance into a unified general equilibrium model of asset pricing. In addition, Lucas demonstrated the compelling and rigorous nature of a rational expectations equilibrium … Before Lucas, the finance literature developed important partial equilibrium models of asset prices (Lucas 1978: 41-42).*

Stanley Fischer presents a similar argument:

> *Aside from its macroeconomics significance, [Lucas, 1972] was influential also in providing a precise model that illustrates the information-conveying role of prices. It was common in the field of finance to say, without any great precision, that in an efficient market prices reflect all relevant information. Lucas model shows exactly what that might mean (Fischer, 1996, 18).*[19]

In his entry "Efficient market hypothesis", Andrew Lo subscribes to the same narrative. After the "landmark" papers by Samuelson (1965) and Fama (1965), it is only "a decade later" (Lo 2008: 3) that rational expectations came to be associated to the efficient market hypothesis. Lo sees this as a turn (operated by Lucas 1978) in terms of the object and methodology, moving away the field of finance from "statistical descriptions" and "empirical testing" and leading it towards a full-fledged "theory of efficient markets".

The main line of this narrative (rational expectations contributed in substantiating an equilibrium concept for the efficient market hypothesis) is not in itself incompatible with

[19] Note that Fischer, conversely to Hall, refers to Lucas (1972)'s model for the neutrality of money, and not to Lucas (1978)'s asset pricing model.

historical literature. However, its chronology (the mid and late 1970s) is puzzling. The existing historical literature portrayed the raise of efficient market hypothesis *in the 1960s* (and not in the 1970) as the strive of financial theorists to anchor their analysis into economic theory and legitimate finance as an academic, scientific discipline within the field of economics (see e.g. Walter 1996; Jovanovic 2008).[20] Therefore, it is *prima facie* odd to think that Lucas's articles published in 1972 and 1978 had an influence on the formulation of the efficient market hypothesis, which is traditionally dated back to Fama's and Samuelson's work almost a decade earlier. Nevertheless, we will see that this narrative, although it requires some qualification and reflexivity, constitutes a relevant lead.

2. The Origins and Early Development of the Association between Efficient Market Hypothesis and Rational Expectations

The discussion of alternative narratives suggests that rational expectations and the efficient market hypothesis were developed independently in the 1960s, and that they were associated later in the 1970s. However, with respect to this encounter in the 1970s, the narratives by practitioners and historical scholarship both provide limited or puzzling accounts. The purpose of this section is precisely to complete and clarify how the two concepts were originally associated and how this association grown stronger.

We start (2.1) by presenting Sargent's "Rational Expectations and the Term Structure of Interest Rates" (1972a) and Modigliani and Shiller (1972)'s reply to Sargent. These, to our best knowledge, are the first published articles explicitly discussing and associating rational expectations and the efficient market hypothesis.[21] We then discuss (2.2) how this debate on

[20] For sure, economic analysis of issues in finance (asset pricing, portfolio choice, …) dates back to much earlier—for instance to the work by Irving Fisher (Dimand 2007). Nevertheless, it was only in the 1960s that a scientific academic community emerged in the US and became firmly established, thanks to the work of Fama, Samuelson and others. Historians note that this breakthrough was not only analytical but also material and institutional—notably through the construction of historical financial data by the Center for Research in Stock Prices at Chicago Business School, and especially the treatment of these data by computers, largely supported the emergence of econometrics. In the same vein, philanthropic foundations led the reform of business school in the 1950s, in which finance practitioners had been replaced progressively by economists and statisticians (Fourcade and Khurana 2013).

[21] This is not to say that there were no other works whatsoever that mentioned explicitly (though incidentally) this association. Nor we argue that some unpublished works might have preceded Sargent's article. In a footnote to his 1972 seminal article, Lucas also clarifies that "The assumption that traders use the correct conditional distribution in forming their expectations, together with the assumption that all exchanges take place at the market clearing price, implies that markets in this economy are efficient, as this term is defined by Roll (1968). It will also be true that price expectations are rational in the sense of Muth (1961)." (Lucas 1972: 110, fn.7) Similarly, Laffer and Zecher (1976), which followed a line of argument very close to Sargent (1972a)'s, was probably completed in

the term structure rapidly found an echo in Fama (1975)'s and how this led him to reformulate the efficient market hypothesis as a rational expectations equilibrium—a reformulation which he achieved in his *Foundations of Finance* (1976a). Finally, we discuss how this reformulation was taken to a further stage when Lucas (1978) disentangled the idea of efficient markets from any statistical characterization (2.3).

2.1 The Origins: Sargent, Modigliani, Shiller, and the Term Structure of Interest Rates

Sargent (1972a) contributed to the debates about the term structure of interest rates or "yield curve", i.e. the observed relation among the interest rates of bonds that differ only in their maturity. Different theories explaining this relation have been originally devised by Irving Fisher (1896), John Hicks (1939), and Friedrich Lutz (1940).[22] In the 1960s, the debate was reinvigorated by the blossoming of econometric testing of these theories (see in particular Meiselman 1962; Wood 1964; Modigliani and Sutch 1966; 1969; Hamburger and Latta 1969). The main contention of the 1960s debate was the explanatory power of the so-called "expectations theory" of the term structure. The expectations theory simply states that, for a bond market respecting a non-arbitrage condition, current long-term interest rates should be equivalent to the average of current expectations for future short-term interest rates. Alternative theories suggest that the interest rate differential between long-term and short-term bonds should reflect not only expectations, but also a premium for liquidity and/or risk.

Although very simple, the expectations theory constituted an obvious challenge in terms of econometric testing, since it entailed producing some sort of measurement for expectations on the future interest rates. In their work, Modigliani and Sutch (1966; 1967; 1969) suggested to formalize current expectations as distributed (hump-shaped) lags of past interest rates—in short, as "adaptive" expectations—so that data on past interest rates will allow to quantify current expectations on future rates.[23] Modigliani and Sutch also concluded, from their empirical estimations, that the expectations theory alone did not satisfactorily explain the data, while the fit of the model was considerably improved by adding an additional "risk premium" term. Sargent was not the first to investigate the term structure within the framework of efficient

1971 or 1972 at University of Chicago, although it was published only 4-5 years later (we would like to thank Edward Nelson, who pointed this out to us).

[22] See Brillant (2019) for a historical perspective on these contributions.

[23] Meiselman (1962) suggested that expectations are formed through a learning process from past errors; Kane and Malkiel (1967) used questionnaires to measure directly expectations. However, they also concluded that their measurements supported Modigliani and Sutch's hypothesis of adaptive expectations.

market hypothesis. This issue was first discussed by Roll in his PhD dissertation *The Behaviour of Interest Rates: An Application of the Efficient Market Model to US Treasury Bills* (Roll [1968] 1970), which stimulated Sargent's research interest in this topic (Sent 1998: 33-34).

In his 1972 paper, Sargent suggested both an alternative way of testing the expectations theory of the term structure ("expectations hypothesis" in his words) and a different specification for expectations:

> *This paper reports some tests of two important hypotheses ... The first is the "expectations hypothesis" ... The second hypothesis is that expectations of investors are rational in the sense of John F. Muth. By this we mean that investors' expectations are equivalent with the optimal forecast of statistical theory for a certain specified class of statistical models. A convenient way to characterize a market that satisfies both of these hypotheses is as an "efficient market". (Sargent 1972a: 74)*[24]

For Sargent, the two "hypotheses" (the expectation theory of the term structure on the one hand, and rational expectations on the other hand) had one single implication, i.e. that the bond market was "efficient". Following the many examples developed in the previous decade by the literature on the efficient market hypothesis, it was straightforward to test this outcome: in short, both hypotheses would be corroborated if forward interest rates were proven to follow a martingale.[25]

Sargent followed the same argument than Samuelson (1965)'s model about the relation between spot and future prices in commodities market. The spot one-period interest rate R_t could be represented by a probability distribution. The expectation theory implies that the current forward interest rate for a future period (that we note F_t^{t+j}, a forward interest rate determined at t, for a bond maturing at $t+j$) should be related to the expectations of the spot interest rate in this future period (R_{t+j}). If we then assume that expectations about R_t are rational, then the expected value of the spot interest rate should be equal to the forward interest rate, conditionnally to the available information I_t:

[24] Sargent credited, in a footnote, Roll ([1968] 1970) and Fama (1970) for devising the expression "efficient market". It could also be argued, although this was not explicit in the article, that Sargent was inspired by Fama (1970)'s idea that the test of the efficient market hypothesis is a "joint test" of the hypothesis *and* of an underlying pricing model.

[25] Sargent (1972a: 75) credited Samuelson (1965) for the martingale model, and Roll ([1968] 1970) as the first having tried to test the distribution of interest rates—indeed, the efficient market hypothesis was mostly tested, along the 1960s, on stock market data.

$$F_t^{t+j} = E[R_{t+j}|I_t]$$

It results from this equation and the iterative expectations law (see Campbell, Lo, and MacKinlay 1997) that that the sequence F_t^{t+j} is a martingale:

$$E\left[\, F_{t+1}^{t+j}|I_t\right] = \, F_t^{t+j}$$

However, Sargent's estimations rejected this martingale distribution, and therefore the efficiency of the bond market. Nevertheless, Sargent was reluctant to take this result as a rejection of either rational expectations or of the expectations theory of the term structure. In his conclusion, he clarified how he did not consider as valid solutions "diluted forms of the expectations theory", such as the liquidity premium, since, although practical in fitting the data, they also were "arbitrary", i.e. they did not rely on any theoretical justification (Sargent 1972a: 94). Abandoning rational expectations was equally unacceptable: to Sargent, this would entail violating the non-arbitrage condition (embedded in the expectations theory), since "non-optimal" (i.e. non-rational) expectations would result in unexploited profit opportunities (*ibid*.).

Shiller (1972b) wrote a first comment about Sargent (1972a); then came a longer answer by Modigliani and Shiller (1973).[26] First, Shiller and Modigliani acknowledged that the discussion could be framed as a test of the "efficiency" of the bond market, following the literature in finance. Secondly, they accepted the idea that, in the context of an efficient market, expectations should be "optimal forecasts" or "best guesses". However, Modigliani and Shiller considered that "extrapolative expectations" *did abide by this definition* (i.e. that expectations based on a weighted sum of past rates did minimize the prediction error for future rates).[27] Sargent's negative result about the martingale, they argued, indicated precisely the importance of *past* rates (Modigliani and Shiller 1973: 29). Second, they suggested that past inflation rates represented a relevant variable to predict long-term interest rates. This argument was already

[26] It was natural to Shiller to enter in this debate, since his PhD dissertation was on the "Rational Expectations and the Structure of Interest Rates" (1969-1972, under Modigliani's supervision at MIT) and Sargent was his colleague at University of Minnesota from 1972 on. Moreover, it is important to note that Shiller (1972b) and Modigliani and Shiller (1973) mostly relied on two ideas developed in Shiller (1972a)'s dissertation.

[27] In Shiller dissertation (1972a), the main model represented the interest rate for the n-period (long run interest rate) as equivalent to a linear combination of the future one-period rates, which are "forecasted on the basis of any subset of the forecasting variables used by the market plus an error term". This meant that the relation forecasted *by the econometrician* could rely only on a *subset* of what was used by actual market participants. Typically, such subset would include only past one-period interest rates (as discussed in Shiller 1972a*:* 36-39**)**. Despite this asymmetry between the econometricians and market participants, the forecast obtained was proven to be "optimal" (in a least-square sense; Shiller 1972a.: 12-14). The idea that there was an asymmetry between the information used by the econometrician and the information used by economic agents was obviously in contrast with the usual definition of rational expectations in Muth and in new classical macroeconomics. However, Shiller did not discuss this latter issue in his dissertation (which, for instance, contained no citation of Muth's paper).

formulated in Shiller (1972a: 16) and was inspired by Modigliani and others' work for the FRB-MIT-Penn Econometric Model (Acosta and Rubin 2019: 478-479).

2.2 The Early Development: Fama on the Term Structure and the Reformulation of the Efficient Market Hypothesis

The discussion on the expectations theory of the term structure continued in the following years. Other contributors entered the debate (e.g. Cargill 1975; Hamburger and Platt 1975; Laffer and Zecher 1976).

Sargent also indirectly replied to Shiller and Modigliani's arguments in "Interest Rates and Prices in the Long Run: A Study of the Gibson Paradox" (Sargent 1973). The main point of contention between Sargent and Modigliani-Shiller was the role of inflation in the determination of long-term interest rates.[28] First, Sargent argued that inflation rates (or inflation levels) were not a relevant variable for predicting interest rates. Such relation, as estimated by Modigliani-Shiller, relied on the idea that inflation rates causally determined interest rates: for Sargent, on the contrary, causality was "two-way", hence the two variables were "mutually determined" (Sargent 1973: 447), as he had already argued in previous work (Sargent 1969; 1972b). Second, Sargent supported again that past interest rates do not follow "naive extrapolations of past rates" à la Modigliani-Shiller.[29] As a conclusion, Sargent followed a line of argument built around the idea of "efficient market": past inflation rates should not contain any relevant information about future rates. the expected inflation rate should be already incorporated in the current nominal interest rate (Sargent 1973: 447).

Fama entered the debate on the term structure, first with "Short-Term Interest Rates as Predictors of Inflation" (Fama 1975), and later in his "Forward Rates and Predictors of Future Spot Rates" (Fama 1976b). The purpose of both articles was to investigate to what extent current interest rates (spot and forward) could be econometrically predicted by past inflation rates and past interest rates, which would be "inconsistent with a well-functioning or 'efficient' market" (Fama 1975: 269).

Nevertheless, we argue that the importance of Fama (1975) rather lies in his reformulation of the efficient market hypothesis "in the language" of rational expectations. It is important to note that, both in Samuelson's and Fama's seminal contributions to the efficient

[28] The so-called "Gibson paradox" points precisely the empirical positive correlation between the price level and the interest rate—contradicting the predictions of the quantity theory of money.

[29] To make his point, Sargent criticized the older explanation of the Gibson Paradox based on Fisher (1930), which served as underlying base for Shiller (1972b) and Modigliani and Shiller (1973).

market hypothesis, the randomness of asset prices was already interpreted using an economic framework (see e.g. Jovanovic 2008). However, in these (and subsequent) contributions, the definition of the equilibrium concept underlying an efficient market was rather elusive. Fama (1965, 94) defined this as asset prices that "represent best estimates of the intrinsic values"—the latter being defined as depending on "earnings prospects of the company, which in turn are related to economic and political factors" (Fama 1965: 36). In further refinements, Fama (1970: 384) clarified how the prices of an efficient market might, for instance, be understood as the equilibrium outcome of the capital asset pricing model (CAPM, or "the two parameters model" in Fama's words).[30] Fama (1975) lied down the foundations of a new definition of the efficient market hypothesis through rational expectations, which Fama will then popularize in his book *Foundations of Finance* (1976a).[31] In Fama (1975: 270-271, equation 6-8), the notion of "best estimate" on future returns was reformulated for the first time following Muth's definition of rational expectations. The "best estimate" of future real interest rates was the mathematical expected value given all the available information, and it was interpreted as 'market participants use the correct conditional distribution to form their expectations'.[32] As in Sargent (1972a; 1973), this implied that past inflation and past interest rates had no predictive power on current interest rates, which can be tested empirically by proving that interest rates follow a martingale.

2.3 Taking a Step Forward: Lucas (1978)'s Asset Pricing Model

Like Fama (1975), Lucas' "Asset Prices in an Exchange Economy" (1978) laid down new theoretical foundations for the efficient market hypothesis based on rational expectations equilibrium models. Lucas explicitly set his article as a contribution to finance and to the literature on the efficient market hypothesis. In this respect, he connected both his result and his assumptions to Fama *and* Muth:[33]

> *The analysis is conducted under the assumption that, in Fama's terms, prices 'fully reflect all available information,' an hypothesis which Muth (1961) had earlier termed 'rationality of expectations.' (Lucas 1978: 1429)*

[30] However, the definition embedded into the CAPM relied on a one-period analysis, where expectations were exogenous and not rational (see Sharpe, 1965).

[31] Fama (1976c) also used this new formulation to answer LeRoy (1976)'s criticism of Fama (1970)'s definition of the efficient market hypothesis.

[32] However, Fama did not explicitly refer to Muth; nor did he use the term "rational expectations".

[33] Like Sargent (1972a), Lucas (1978: 1444, fn. 10) also explicitly referred to Samuelson (1965)'s formulation of the efficient market hypothesis as a martingale. Lucas also referred to LeRoy (1973)'s refinement of Samuelson's model.

In his model, Lucas discussed the dynamic properties of prices of a financial asset, in a single-good pure exchange economy where productivity of firms varies stochastically. In this model economy, financial assets represent "claims on part of the output", which is produced exogenously (i.e. with no inputs) by one among a large number of heterogeneous firms. Households (which were assumed identical) can purchase assets in a "competitive stock market". The problem set by Lucas was thus to determine the price sequence for assets and the produced good, assuming that such prices were market clearing prices (i.e. the prices for which, at each period, households consume all the current output of the economy and they hold all the existing assets). Lucas's result was that the equilibrium asset prices might either follow a martingale process, or they might not. In other words, the statistical characteristics of a sequence of prices was not a *sufficient* condition to draw inference on "efficiency" of markets:

> *With respect to the random character of stock prices, it is evident that one can construct rigorous economic models in which price series have this characteristic (a martingale) and ones with equally rational and well-informed agents in which they do not. This would suggest that the outcomes of tests as to whether actual price series have the Martingale property do not in themselves shed light on the generally posed issue of market 'efficiency'. (Lucas 1978: 1444, Lucas's emphasis)*

A more explicit claim about the *intentions* of the paper was to be found few lines later, where Lucas clarified his *methodological* aspirations:

> *In the main, however, this paper is primarily methodological: an illustration of the use of some methods which may help bring financial and economic theory close together. (Lucas 1978: 1444).*

The bottom line of Lucas's paper was therefore that efficient markets were rather characterized by the equilibrium nature of asset prices (based on rational expectations) than by any particular form of their statistical distribution.[34] We can therefore interpret Lucas's methodological ambition as pushing finance further towards formalizing general equilibrium model of asset pricing, instead of simply pursuing the route of empirical testing of prices distribution. In this respect, Lucas's paper contributed to the process (started earlier, see e.g. Jovanovic 2008) of

[34] Similar arguments were raised later by Sims (1980)'s working paper "Martingale-Like Behavior of Prices."

"anchoring" the efficient market hypothesis, as a field of research, into a theoretical "rigorous" concept of equilibrium" and into a practice of mathematical modelling.

3. Stabilization of the Association and Challenges to the Efficient Market Hypothesis

The previous section illustrated how the association between the efficient market hypothesis and rational expectations had originated and developed. Starting from 1975, several new applications of the association to other topics flourished—for instance, applications to the determination of the exchange rate (Niehans 1975; Dornbusch 1976; Fama 1984). Surveys (e.g. Kantor 1979; Jensen 1978), books (e.g. Mishkin 1983; Sheffrin 1983) on both rational expectations and the efficient market hypothesis started to routinely associate the two concepts. One example is Steven Sheffrin's *Rational Expectations* (1983), a detailed exposition of the rational expectations literature, in which the efficient market hypothesis was viewed as an application of rational expectations to financial issues.[35] Sheffrin's exposition already matched with the modern textbook presentation of the association between the two concepts (*cf.* Introduction).

The association remained very much into the background of new classical macroeconomics, which implicitly or explicitly assumed efficient financial markets until very recently (see e.g. Vines and Wills, 2018). Conversely, the association has been at the centre of new research programs in the field of finance. In this section, we discuss two examples of these new developments: Shiller's test of volatility and the Grossman-Stiglitz paradox. A shared and somehow paradoxical characteristic of these works is that they did not *reject* the association of the two concepts *per se*; conversely, they *embraced it* in order to criticize standard formulations of the efficient market hypothesis. Thus, these new research programs also contributed to further popularize the association between rational expectations and the efficient market hypothesis.

From the perspective of the broader dialogue between (macro)economics and finance, the research programs discussed below are also representative of the moving boundary between the two fields (see e.g. Summers 1985; Ross 1987). These research programs were mostly raised

[35] Sheffrin argues that by the time he was writing his book, the association "was widespread. We often would talk about using regression models for rational predictors, so that the error terms in prediction were orthogonal to the regressors. For efficient markets, the 'regressors' would include publically available information. We realized that rational expectations was a deeper, model based concept but some of its immediate implications applied to efficient markets." (Sheffrin, pers. comm., February 14, 2020)

by outsiders to financial economics;that is, scholars mostly trained in economics departments in the 1970s, and not in finance departments in business schools (Fourcade and Khurana 2013). Moreover, these scholars used more intensively theoretical models to address topics in finance (in particular, though not exclusively, rational expectations equilibrium models to address market efficiency). Although sophisticated empirical analysis remained highly fashionable in finance, this shift towards a more formal and theoretical approach echoed Lucas (1978)'s methodological ambition.

3.1 Shiller and the "Anomalies" of the Efficient Market Hypothesis

It is widely acknowledged that, within finance, the 1980s have been characterized by several empirical challenges against the efficient market hypothesis (see e.g. Wang 2008). The formulation of efficient market hypothesis *based* on rational expectations became the benchmark, against which "anomalies" of market efficiency were detected (see for instance, Jensen 1978: 95).[36]

The perhaps most illustrative examples of this line of work are Shiller's twin papers "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure" (Shiller [1979] 1981a) and "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?" (Shiller [1980] 1981b).[37]

Shiller's methodology for testing the efficiency of the bond market was original, insofar it did not start, as in the past literature, from a statistical assessment of the random character of the interest rate. Conversely, Shiller began with developing a simple class of linear rational expectations models of the long-term interest rate. As such, the current (t) long-term interest rate (R) for a bond maturing at time n (R_t^n) should be equal to the present expected value of the sum of one-period interest rate (r_t):

$$R_t^n = \frac{1-\gamma}{1-\gamma^n}\sum_{K}^{n-1}\gamma^K E_t(r_{t+K})$$

[36] Note that this also implied a reassessment of the methods for testing the efficient market hypothesis. Somehow relating to Lucas (1978) intuition, traditional tests of stock or bond prices as random walks or martingales were progressively complemented with tests about "above-average profitability" (Summers 1986: 591-592) or "excessive volatility" (*cf*. Shiller *infra*).

[37] For the stock market, LeRoy and Porter (1981) provided similar results to Shiller's (1981a [1979]).

with γ the inverse of the discount factor.[38] Shiller notes then that long-term interest rates, as defined by the above equation, could be computed using observed short-term interest rates (r_t^*) and assuming a value of $\gamma = 0.98$. Such "ex-post rational rates" are:

$$R_t^{n*} = \frac{1-\gamma}{1-\gamma^n}\sum_{K}^{n-1}\gamma^K(r_{t+K}^*)$$

When comparing the series of ex-post rational rates above with the actual (observed) series of long-term interest rates for 1966-1977, the discrepancy between the two plots became apparent: the actual rates were much more volatile than the ex-post rates predicted by the rational expectations model (Shiller [1979] 1981a: Figure 1 and Figure 3). This disqualified an explanation of long-term rates as the "averaging implicit in rational expectations models" of short-term rates (Shiller [1979] 1981a: 1192). Although the integration of "new information" into expectations could eventually justify the observed volatility, Shiller argued that it was unlikely that such "new information" would appear that often, and that long-term rates seemed rather "disturbed by transient effects unrelated with expectations" (Shiller [1979] 1981a: 1214).

Shiller's paper ended with a statistical analysis of the discrepancy between the ex-post rates and observed rates. Notably, Shiller introduced for the first time a set of zero-covariance restrictions on observed long-term and short-term rates, in order to test the efficiency. These restrictions were violated by data. This casted further doubt on the efficiency of the bond market, since non-null covariance implied "forecastability" of rates, contradicting the efficient market hypothesis.

Shiller ([1980] 1981a) extended this reasoning to the volatility of stock prices: he highlighted how the observed volatility of these prices seems inconsistent with a rational expectations model which expressed the equilibrium price of stocks as their expected returns (measured as the ex-post observed dividends). As for bonds, the excess volatility of the observed stock prices was combined with a violation of zero-variance restrictions, therefore implying the existence of profit opportunities (Shiller [1980] 1981a: 423-424).

Several other contributions (e.g. Summers 1986; De Bondt and Thaler 1985; Poterba and Summers 1988) followed up on Shiller's idea—although with different angles.[39] With

[38] The original version of the model also included a constant liquidity premium, which was omitted here for sake of simplicity. As the reader will note, the core of Shiller's formalisation was simply a rational expectations version of the expectations theory of the term structure, precisely as suggested by Sargent (1972a).

[39] Summers and Poterba focused on the mean-reversion phenomenon, as further evidence of possible misevaluation of assets prices. De Bondt and Thaler focused on market "overreaction" (i.e. the tendency of market participants to overweight new information and underweight prior information) as a possible explanation of the

respect to the association between rational expectations and the efficient market hypothesis, we consider that these works illustrate the following. On the one hand, they have been taking seriously this association, since all rely on the assumption of rational expectations to produce tests of market efficiency. For instance, Shiller used the association to address the same issue of term structure of interest rates he addressed without the association ten years before. However, on the other hand, based on these tests, these works have been rejecting the predictions of the rational expectations version of efficient market hypothesis. Nevertheless, and most interestingly, their findings on the "inefficiency" of the bond and stock market have not been the end of the line for these authors. Conversely, their goal became, as Shiller put it, to find alternative answers to a "more interesting (from economic standpoint) question: what accounts for movements of real stock prices?" (Shiller [1980] 1981b: 424) Price valuation became indeed the central issue for the rise of behavioral finance (Shiller 1984; De Bondt and Thaler 1985). This entailed, precisely, the development of several explanations of asset prices determination, all relying on assumptions about individual behavior that clearly departed from the optimizing rationality implicit in the rational expectations hypothesis.

3.2 Grossman and Stiglitz's Paradox

The development of alternative theoretical insights by behavioral finance arise from an empirical criticism of the predictions of the efficient market hypothesis associated with rational expectations. A different research path result from a more theoretical and logical criticism. One example is the literature on "rational bubbles" (Blanchard 1979; Blanchard and Watson 1984; Tirole 1982; Tirole 1985). Like the new resedearch program on price valuation, the literature on rational bubbles illustrated that, within rational expectations models, asset prices' could depart from their efficient price—although this literature was rather interested in rigorously formalizing bubbles than in supporting or criticizing a particular assumption on rationality (e.g. Tirole 1982: 1180).

Another example of this line of theoretical or logical criticism is the new literature in finance which used rational expectations as a benchmark to model and discuss the circulation of information in financial markets. The seminal paper for this line of research was Grossman and Stiglitz's "On the Impossibility of Informationally Efficient Markets" (1980), famously

excessive volatility highlighted by Shiller. However, several other contributions actually criticized Shiller's method and result (for a short summary see Fama 1991: 1586; Shiller 2003: 84-90).

rebranded the "Grossman-Stiglitz paradox".[40] The model developed by Grossman and Stiglitz relied explicitly on Lucas (1972) incomplete information model (a seminal model for new classical macroeconomics) in which expectations are formed rationally in the sense of Muth. Grossman and Stiglitz used Lucas's model to investigate if efficient prices (i.e. "prices reflecting all available information") were a property of a rational expectations equilibrium model (Grossman and Stiglitz 1980: 393).

Grossman and Stiglitz's model described a market featuring two types of individuals: "informed traders", who have acquired, at a fixed cost, information on the future returns of a financial asset; and "uninformed traders", who have decided not to pay for information. The latter, from observing the asset price on the financial market, can only *infer* (with no cost whatsoever) information about future returns. However, this inference is not perfect: even if the asset price reflects some of the information about information about future returns (acquired by informed trader), the price also reflects noise generated from a stochastic component.[41] Market participants will acquire information only if its marginal cost is less than its expected utility, that is, the profits they are expecting from the financial asset. The equilibrium (i.e. the absence of profits opportunities) occurs when the expected utility of the informed traders equals the expected utility of the uninformed traders. If the expected utility of informed traders is greater than those of uninformed traders, then some of the uninformed traders switch to the informed traders group. If the population of informed traders increases, their expected utility decreases since (a) the relative gains of informed traders on uninformed traders decrease. Furthermore, (b) if the population of informed traders increases, an information has greater impact on price (relatively to noise) and then more information is available to the uninformed.

After proving the existence of an equilibrium of this economy, Grossman and Stiglitz investigated notably the case where the price "fully reflect all information" as defined by the efficient market hypothesis. Their model showed that, if the price "fully reflect[s] all information" and information is costly, then the market collapses. Indeed, since the price reveals all the information, informed traders would stop paying for this information. Since all traders behave identically, they should then all become uninformed; however, if all agents are uninformed, there is then a profit opportunity for those that would decide to purchase information. Hence, Grossman and Stiglitz showed that freely available information is not only

[40] Note that the paper draws on the authors' previous work on the role of information in determining market equilibrium (e.g. Grossman and Stiglitz,1976).

[41] In the Lucas (1972)'s analogue model, agents observing individual prices could not distinguish changes in relative prices from changes in nominal prices.

a *sufficient* condition for the efficient market hypothesis to hold, but that it is a *necessary* condition. However, if the information is freely available, then, the authors argued, financial markets and competitive prices become purposeless, since their role should be precisely to convey information.

Grossman and Stiglitz did not aim at challenging the efficient market hypothesis, although they did want to redefine it under less restrictive conditions (incorporating inefficiency and costly information). Their attempt to redefine the efficient market hypothesis is of much interest to the conclusions of our paper, insofar as it was based on a rational expectations model. This contributed to the development of a new literature analyzing the information transmission in financial markets: see, for instance, the no-trade theorems (Milgrom and Stokey 1982; Tirole 1982), the noise traders (Black 1985; De Long et al. 1990), and the issue of information aggregation (Hellwig 1980; Diamond and Verrecchia 1982; Admati 1985; Kyle 1985). In this literature, the efficient market hypothesis was not taken as a theory subject to empirical test, but rather as a given since these works analyze the idea that price incorporates information.

Conclusive remarks

This article investigated the theoretical origins and early development of the association between rational expectations and the efficient market hypothesis. The history of the association illustrated the moving boundary between macroeconomics and finance. The contributions we have scrutinized certainly showed a stronger relationship between the two fields that emerged throughout the 1970s, though further research should characterize more precisely this relationship.

Beyond the analytical aspects of the association, some scholars used it to make a point about economic policy. For instance, Mishkin (1978; 1983) relied on the literature on the efficient market hypothesis to support the new classical proposition about "policy ineffectiveness" and the new classical critique of large-scale macroeconometric models (Lucas, 1976):

> *efficient-markets theory implies that the macro-econometric models currently used for policy analysis and forecasting are deficient in a fundamental way. (Mishkin 1978: 709)*

Moreover, Miskhin argued that large-scale macroeconometric models assumed that monetary policy affecting money supply will thus affect the short-term interest, which, in turn, will affect long-term interest rate (through term structure). Henceforth, if the bond market was efficient,

predictable monetary policy would have no effect on interest rates, since the information about current and future expected monetary policy would be already incorporated in current rates. Following Lucas (1972), Miskhin claimed that discretionary monetary policies were then ineffective or counterproductive.[42]

It should be noted that not everyone agreed about the way the relationship between macroeconomics and finance led to this kind of conclusion on economic policy. Modigliani picked up directly on Mishkin (1978)'s use of the efficient market literature, which he bluntly rejected as "unwarranted" and "based on confusion" (Modigliani 1978: 757). The case of Samuelson is another illustrative example of this disagreement. Samuelson (1965)'s theoretical work on efficient markets (rather than Fama 1965) constituted the backbone of the rational expectations models of asset markets developed by Sargent (1972a) and Lucas (1978). However, Samuelson strongly rejected any association between his formulation of the efficient market hypothesis and rational expectations supported by new classical macroeconomics (Boianovski 2019).[43] Samuelson considered that those ideas were relevant only to financial issues, and even more particularly to the assessment of actual investment strategies (Delcey 2019). These two examples illustrate how the disagreements about the association was entangled with more than theoretical issues, and notably with economic policy issues.

These debates might be related to the asymmetrical influence of the association on, respectively, finance and macroeconomics. As we have shown in section 3, the association between rational expectations and the efficient market hypothesis had driven fruitful research programs in the field of finance, in particularly by questioning the conditions under which financial markets might be deficient. We suggested that, by contrast, the influence of the association on macroeconomics research appears as less fruitful. Macroeconomics seems to have implicitly relied on the efficient market hypothesis to describe the functioning of financial markets and their impact on macroeconomic variables, at least until the very recent discussions about financial stability following the great financial crisis.

[42] In a similar vein but in a different context, Lucas used examples from the efficient market literature to illustrate his position on economic policy, during a speech given in March 1977 and organised by Mitchell, Hutchins Inc., a Wall-Street-based financial firm (Box 39, Folder Mitchell, Hutchins Conference. Robert E. Lucas Papers, 1960-2011 and undated. David M. Rubenstein Rare Book and Manuscript Library, Duke University).

[43] "It is a mistake, albeit a common one, to believe that the hundreds-of-thousand bit of evidence that bear out market microefficiency thereby lend credence to the macroefficiency arguments that go under the fancy title of the School of Rational Expectations (the "new Classical School" of Robert Lucas and Thomas Sargent […]" ("The Morning After", speech at NYU, 20 October 1987. Speech and Interviews Series, Box 121, Paul A. Samuelson Papers, 1933-2010 and Undated. David M. Rubenstein Rare Book and Manuscript Library, Duke University).

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