The Efficient Market Hypothesis and Rational Expectations: How Did They Meet?

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Abstract

The efficient market hypothesis and rational expectations are today distinctive theoretical benchmarks for mainstream approaches to, respectively, finance and macroeconomics. Moreover, academics in each of these two fields associate the efficient market hypothesis and rational expectations. The ground for such claim is that both are equilibrium concepts, closely related (or equivalent) and mutually consistent; moreover, it is claimed that they have a common history.

This article investigates the historical and theoretical origins of this association. Although solid historiographies have been built about either rational expectations or the efficient market hypothesis, very few contributions have been trying to investigate the history of the association between the two concepts (and, more broadly, to investigate the relations between the two fields). The contribution of this paper is precisely to fill this gap in the historical literature, while assessing and challenging the self-produced narratives of practitioners.

We show how the association between rational expectations and the efficient market hypothesis was born in the early 1970s within a debate about the term structure of the interest rates between (among others) Thomas Sargent, Franco Modigliani and Robert Shiller, and Eugene Fama. The association then came to form a step-stone for both macroeconomics and finance. In macroeconomics, the reference to the efficient market hypothesis played a threefold role: it provided early empirical support to rational expectations; it offered a microeconomic rationale for the treatment of money in general equilibrium macroeconomic models; and, finally, it set a theoretical benchmark for the development of general equilibrium macroeconomic models without financial frictions. In finance, the reference to rational expectations contributed to further anchoring this field into an "equilibrium discipline" and fostered the idea of "joint test" of the efficient market hypothesis.

Keywords: Efficient market hypothesis, rational expectations, history of macroeconomics, history of finance, Fama (Eugene), Lucas (Robert E.), Sargent (Thomas J.)

JEL codes: B22, B26

Introduction

The efficient market hypothesis and rational expectations are today distinctive theoretical benchmarks 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.

In contemporary literature in finance, the efficient market hypothesis is usually attributed to Samuelson (1965) and Fama (1965), and 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 (Walter, 2006; Vuillemey, 2013). Conversely, rational expectations (attributed to Muth, 1961) do not dispose of a standard, widespread, and synthetic definition (e.g. Sent, 1998, Introduction). Thomas Sargent, in his entry "Rational Expectations" for the *New Palgrave Dictionary of Economic*, summarizes rational expectations as "an equilibrium concept that attributes a common model … to nature and to all agents in the model" (Sargent, 2008, 1).[1] The idea of "common model" leads to the key implication 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" (*ibid*.) The association between rational expectations and the efficient market hypothesis relies on this implication, postulating that asset prices that "reflect fully all available information" is equivalent to a "best" or "optimal" forecast of the asset future return. For instance, the most popular textbook on financial economics, Frederic Mishkin's *The Economics of Money, Banking, and Financial Markets* (2016),[2] presents rational expectations as expectations that "will be identical to optimal forecast (the best guess of the future) using all available information" (Mishkin, 2016, 192).[3] The explanation goes on demonstrating how rational expectations "apply" to the pricing of assets. Since asset prices should reflect expected future returns (e.g., for stocks, the expected discounted sum of future dividends, *ibid*. 190), it follows that non-optimal forecasts (i.e. non-rational expectations) would lead to over-pricing or under-pricing of assets (i.e. the

[1] 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".

[2] Other popular textbooks for finance organise the presentation of the efficient market hypothesis following exactly the same structure and line of reasoning as Mishkin's (e.g. Burton et al., 2010). Some textbooks for macroeconomics also adopt the same view (e.g. Burda and Wyplosz, 2013).

[3] 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".

current price implies higher or lower future return than what is implied by "the best guess"; *ibid*. 196-197). Avoiding such unexploited opportunities for profit provides the rationale for market participants to converge toward optimal forecasting (arbitrage), i.e. to converge toward an equilibrium price equivalent to the "best guess".[4]

The legitimacy of this association is also supported by claims about the common history of the two concepts. Such claims are found in self-produced historical narratives, i.e. historical accounts produced by practitioners in macroeconomics or in finance. These narratives trace back the origins of the association between the efficient market hypothesis and rational expectations to the 1960s, and they use two different lineages to explain these origins. On the one hand, most financial economists claim that rational expectations were implicitly "discovered" or "brought into fashion" by works in their field associated with the development of the efficient market hypothesis in the 1960s. In a nutshell, this narrative argues that the blossom of the efficient market hypothesis has been the forerunner of the later development of rational expectations in macroeconomics in the 1970s. On the other hand, some financial economists and most macroeconomists hold the reverse narrative: inspired by John Muth (1961), the success of rational expectations in macroeconomics during the 1970s contributed to the development of the efficient market hypothesis in finance around the same period.

Both these narratives consist of incidental or anecdotal remarks on the margins of dictionary entries, textbooks, literature reviews, or autobiographical accounts. As such, they rely on sketchy historiographical foundations and scarce evidence. However, historians of economics have not much more to offer. Although we dispose of solid historiographies about either rational expectations or the efficient market hypothesis, very few contributions have been investigating the history of the association between the two concepts (or the relations between the two fields in general; the most notable exception is Hoover, 1988, ch. 5). The purpose of this paper is precisely to fill this gap in the historical literature, which will cast new light upon the development of macroeconomics and finance in the 1970s and the 1980s.

Our investigation starts with an exploration of self-produced narratives (section I) and an assessment of such narratives based on historical literature and evidence (section II).

[4] Note that the actual consistency of this association could be questioned. Take, for instance, the epistemological status of the "common model" assumption. Rational expectations in macroeconomics cautiously take an instrumental position, defining rational expectations as an assumption pertaining solely to the "world in the model" (e.g. Hoover, 1988). While the efficient market hypothesis usually does takes the symmetry between nature (the market) and investors as a claim about "real world" behaviour of certain market participants ("sophisticated investors" or "sophisticated traders"). However, this and other issues about the actual consistency of the contemporary association will not be addressed here, since they are outside the scope of our paper.

Conversely to the what is claimed in self-produced narratives, we found no evidence, for the 1960s, of any common origins or lineage between rational expectations and the efficient market hypothesis; it seems therefore that the two concepts should be characterized as independent developments, stemming from distinct research programs.

We then analyse (section III) the first instance of the association between the two concepts in the early 1970s, which have been so far neglected by both the history of macroeconomics and the history of finance. Thomas Sargent (1972)'s article was the first published contribution stating 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 Shiller and Modigliani (1973)[5] and Fama (1975), reframed the (pre-existing) empirical debate about the theories of term structure of interest rates, making the association between rational expectations and the efficient market hypothesis a cornerstone of that debate.

Following the developments of the debate on the term structure, a dialogue was established between macroeconomics and finance, and the association between rational expectations and the efficient market hypothesis became, by the end of the 1970s, a step-stone for both fields (section IV). We illustrate how, in the early 1980s, the association was already stabilized under the form that is still preeminent in contemporary literature (*cf.* supra), as illustrated by Mishkin (1983) and Sheffrin (1983). This stabilization sealed the role of the association in driving new developments for both fields.

In macroeconomics, and more specifically within the research program set in motion by Robert Lucas, the reference to the efficient market hypothesis helped in supporting two lines of theoretical development. First, the efficient market hypothesis provided a microeconomic rationale for the treatment of money in general equilibrium macroeconomic models. Second, the efficient market hypothesis provided the theoretical benchmark for the development of general equilibrium macroeconomic models without financial frictions. Finally, referring to the efficient market literature represented, for Lucas and co-authors, an additional argument for supporting their own research program: since the efficient market hypothesis was perceived as relying on broad and solid empirical evidence, rational expectation would benefit of that empirical support through the association of the two concepts.

[5] Stemming from Shiller's PhD dissertation supervised by Modigliani (1969-1972).

In finance, the reference to rational expectations played a twofold role. On the one hand, it contributed to further anchoring this field to an "equilibrium discipline"—therefore amplifying and fostering the process initiated in the 1950s and 1960s (Jovanovic, 2008). On the other hand, the reference to rational expectations contributed to empirical developments, notably to the idea of "joint test" of the efficient market hypothesis (i.e. the simultaneous test of an underlying equilibrium model and of its outcome in terms of price dynamics).

Moreover, the association between rational expectations and the efficient market hypothesis became also the backbone of debates and controversies. By the end of the 1970s, while the association was stabilizing in both fields, several contributions used the association as a starting point of their criticism of either the efficient market hypothesis or rational expectations' macroeconomics. In the last part of this article, we focus in particular on finance, where the concept of rational expectations has been weaponized by several authors (for instance, Sanford Grossman and Joseph Stiglitz, 1980; Shiller, 1979, 1981) to cast doubt into the efficient market hypothesis.

1. Self-produced narratives in contemporary literature

1.1 An overview of the different lineages

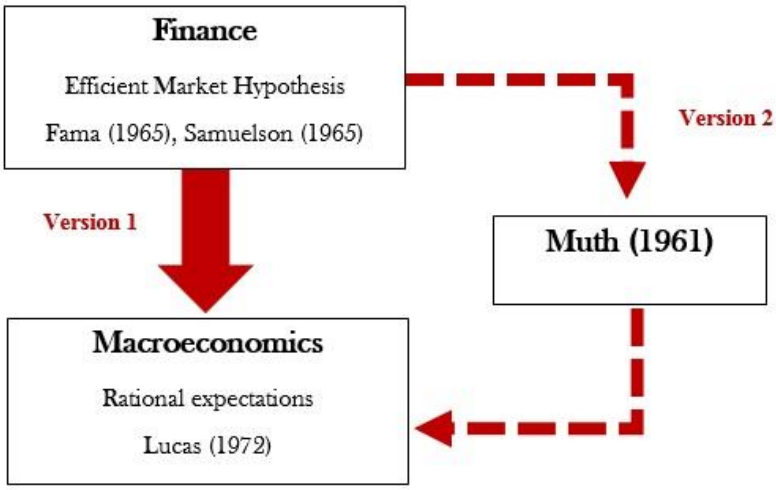
This section explores and assess the self-produced narratives about the origins of the association between rational expectations and the efficient market hypothesis. To reconstruct these narratives, we rely on four different types of source: (i) dictionaries (e.g. *The New Palgrave Dictionary of Economics*); (ii) textbooks in macroeconomics and in finance; (iii) literature reviews and surveys on the efficient market hypothesis; (iv) personal memories by economists involved in the development of both approaches (oral history and autobiographies). We follow here the approach taken by other historiographical work on "self-produced" or "standard" or "canonical" narratives.[6] Accordingly, we focus on sources that are illustrative of "stabilized" or "consensual" knowledge, which play a key role in structuring, showcasing and reproducing the state of a field.[7]

[6] See for instance, for macroeconomics, Duarte and Lima (2012) and Sergi (2019), and, for finance, Jovanovic (2008).

[7] For a discussion of the case of textbooks, see Giraud (2018). Concerning the literature reviews on the efficient market hypothesis they played a distinctive role in this field. From Fama (1970) onward, literature reviews were instrumental in the consolidation of concepts, in fixing new orientations for the research program (e.g. Fama, 1991), and raising criticisms against the efficient market hypothesis (e.g. Jensen, 1978) and counter-attacks (e.g.

From our analysis of these sources, we identify two opposite claims: on the one hand, a vast majority of narratives locate the origins of the associations between rational expectations and the efficient market hypothesis in the 1960s, when one concept "influenced" or "inspired" the other; on the other hand, few narratives, mostly arising from autobiographical accounts, argue that no connection between the two ideas was established during the 1960s, and that they arose as "independent discoveries". We will argue, in section 2, that the latter account is the only one that seems supported by the *available* historical evidence. Nevertheless, we start with analysing here at length the first account.[8]

Claims about a "1960s connection" between the efficient market hypothesis and rational expectations can be further separated into two different stories, or two different "lineages", each one corresponding to a different family tree. The first lineage (see figure 1 below) considers the efficient market hypothesis as the "ancestor" of rational expectations in macroeconomics, either as a direct ancestor (version 1) or as an indirect ancestor through Muth (version 2).

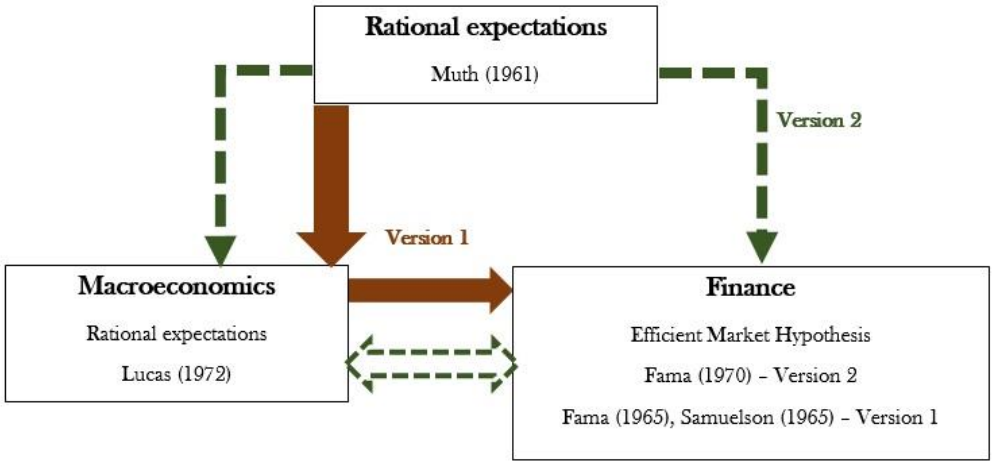


Conversely, the second lineage (see figure 2) puts Muth's paper on top of the family tree, i.e. considers him as the "ancestor" of both the efficient market hypothesis and new

Malkiel, 2003). As noted by Jovanovic (2008), these literature reviews have also key in establishing a "canonical history".

[8] There are at least two reasons to engage with these narratives despite their apparent unreliability. First, because we cannot rule out that new evidence would eventually prove that an early connection between the two concepts was indeed established in the 1960s—in this case, our reconstruction here of these narratives could eventually provide useful leads for future research. Secondly, our investigation does not aim at "getting the historical record straight" and "correct" unsupported claims made by self-produced narratives. Our purpose is rather to unveil how and why rational expectations and the efficient market hypothesis were associated, and what difference this did make into the development of both fields. In this perspective, it is useful to clarify how and why today's practitioners seek historical legitimacy for this association by telling different kinds of stories.

classical macroeconomics. There are, however, two slightly different versions of this lineage for what concerns the association between the two fields. The most widespread version (version 2 in figure 2) identifies Muth as the common source of parallel developments *aware of each other*. The second version (version 1 in figure 2) argues that rational expectations in macroeconomics in the 1970s have been responsible for the blossom of the efficient market hypothesis.



1.2 Lineage 1: From finance to macroeconomics

The first lineage identifies the efficient market hypothesis as the "ancestor" of rational expectations, i.e. it claims that works in finance about the efficient market hypothesis in the 1960s have been the forerunners of the use of rational expectations either with respect to Muth or with respect to new classical macroeconomics. A central illustration of this claim is Stephen Ross' "Finance" entry into the *The New Palgrave Dictionary of Economics*. Ross initially focuses on Fama (1965) and earlier works centered around the empirical testing of the "random walk hypothesis".[9] Then, in the section "Theoretical Formulations", Ross introduces the idea of rational expectations, and he acknowledges that Cox et al. (1985) and Lucas (1978) developed rational expectations models "consistent with certain versions of the efficient market theories." (Ross, 2008, 6) He then claims that these developments were "parallel" to the "neoclassical rational expectations view of macroeconomics", and that

[9] Ross qualifies the efficient market hypothesis as one of the four subfields or "topics" of "neoclassical theory of finance", the three other being the study of risk-return relations (notably through the Capital Asset Pricing Model, CAPM), the pricing of options (notably through the Black-Scholes model), and the study of financial structures of corporations ("corporate finance"). Note also that "rational expectations" are not marginalized by this account of finance, since they are one of the keywords associated with this entry.

> *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 (ibid.)*

Another illustration of "lineage 1" is Robert Merton (2006)'s account of Paul Samuelson contribution to finance. Not only Samuelson (1965)'s account of asset pricing could be seen as using (implicitly) rational expectations *à la* Muth; moreover, Merton also argues that Samuelson has been disseminating the ideas of his 1965's article for the decade preceding its publication, through communications in several talks, including a 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).[10]

This lineage (in both versions) surely relies on a consistent chronology (Samuelson drafts of 1965, Muth, 1961, Fama, 1965, Fama, 1970, Lucas, 1972 and 1978). Especially with respect to Ross' claim, it sounds plausible to consider that the efficient market hypothesis has been a source of inspiration for new classical macroeconomics, since the former was already a well-established field by the end of the 1960s, while the latter only started to gained momentum. However, macroeconomists do not acknowledge any "inspiration" coming from finance. For instance, *New Palgrave*'s entries for "Rational Expectations" (Sargent, 2008) and "New Classical Macroeconomics" (Fischer, 2008) do not mention any link with finance or the efficient market hypothesis.[11] If therefore there is an influence or inspiration, it is either neglected or forgotten by macroeconomists. This latter remark leads us to consider the self-produced narrative of "lineage 1" as proper to financial economists. In this context, "lineage 1" fits with a general narrative about the role of finance within economics: finance, as a sub-discipline, was not a marginal field, but a driving force for the development of economics, capable of influencing the development of the discipline as a whole and of other subfields as macroeconomics. This motivation for "lineage 1" is rather explicit in one of Ross' previous surveys on finance (1987), where he argues that "economics, in general will greatly benefit

[10] Note that, relying on Samuelson's archives, Bernstein (1993) disputes this whole narrative, including the fact that the Carnegie's lecture had taken place. As we will see in the next section, there is no evidence supporting any influence of Samuelson on Muth's work, although Samuelson's (and Fama's) formulation of expectations could be seen as reasonably close to Muth's rational expectations.

[11] Blanchard (2016, Global edition, ch. 14), one (if not the most) popular textbook for macroeconomics, takes a similar attitude: no reference to Fama or other works in finance, no use of the expression "efficient market hypothesis", despite devoting a full chapter to financial markets and a section to stocks valuation. Blanchard merely refers to "the random walk hypothesis", although presenting the same content as Mishkin's (2016). Also, the substantial final chapter in Blanchard's textbook, about the history of macroeconomics, does not discuss any relation between rational expectations and finance or the efficient market hypothesis.

from the tools and data developed in finance", taking already as an illustration "early work on efficient markets [which] was the impetus if not the cornerstone of the neoclassical, rational expectations school of macroeconomics" (and then again: "finance gave economics its penchant for rational expectations"; Ross, 1987, 34).

1.3 Lineage 2: From Muth to macroeconomics (and) to finance

Mishkin (2016, 195) distinguishes three historical sets of works in the 1960s and 1970s: the "theory of rational expectations", which he identifies with Muth (1961); "monetary economics", which stands for new classical macroeconomics; and "financial economists", which narrowly designates here those working on the efficient market hypothesis. Mishkin places Muth (1961) on the top of the family tree, while the two other strains followed a "parallel development":[12] "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) 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 (ibid.)*

As we will see in the next section, 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. Self-produced narratives arising from autobiographical accounts are contradictory on this point: while Lucas and Shiller would be skeptical of this connection (*cf. infra*, 1.4), Richard Roll (one of Fama's PhD student) will claim that he was already aware of Muth work while writing his dissertation (1965-1968), "because his fellow students and professors at Chicago had used it as one element in constituting their ideas about market efficiency" (Roll, personal communication, quoted in Sent, 1998, fn 7).

Other textbooks rely on a similar narrative, such as Howells and Bain ("The efficient market hypothesis is just one application of the 'theory of rational expectations' first set out by John Muth", 2013, 573) or Burton et al. ("The Efficient Market Hypothesis: Rational Expectations Applied to Financial Markets, 2010, 146). Blake (2001) rather emphasis that the efficient market hypothesis became well-established during the 1970s and that this "*coincided*

[12] The structure of this chapter of the 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). The same approach is taken by Burton et al (2010).

with the rational expectations revolution that was taking place in other parts of macroeconomics" (Blake, 2001, 398).

A celebrated figure of the new neoclassical synthesis, Michael Woodford, supports the thesis of "lineage 2" in one of his papers on the history of macroeconomics, claiming that Muth's theory "had already found important applications in the 1960s to models of agricultural cycles and of fluctuations in financial markets (Samuelson, 1965)." (Woodford, 1999, 19)[13]

In two papers celebrating Lucas's Nobel prize, we could also find a specific narrative about how rational expectations macroeconomics influenced finance and the efficient market hypothesis. Robert Hall claims that Lucas (1978) "gave structural content to the relationships alluded to in the finance literature" and "integrated ideas from economics and finance into a general equilibrium "compelling and rigorous" model (Hall, 1996, 41-42). In a paper written in the same occasion, Fischer advances the same kind of 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).*[14]

In his entry "Efficient market hypothesis", Andrew Lo subscribes to the same narrative. After "landmark" papers by Samuelson (1965) and Fama (1965), it is only "a decade later" (Lo, 2008, 3) that rational expectations have come to be associated to the efficient market hypothesis. Lo sees this as a turn (marked by Leroy, 1973 and Lucas, 1978) in terms of the object and methods of the field, moving away from "statistical descriptions" and their "testing" and going toward a full-fledged "theory of efficient markets".[15] The same

[13] Woodford (*ibid.*) also argues that the findings about the "random walk" behaviour were a *result* of the use of rational expectations.

[14] Note how Fischer, conversely to Ross, refers to Lucas (1972)'s "islands model", and not to Lucas (1978)'s asset pricing model.

[15] Note that the previous edition of the Palgrave Dictionary of Economics, the entry "Efficient Market Hypothesis" (Malkiel, 1987) did not mention rational expectations at all. The historical account provided in that entry focused on early formulation of the random walk hypothesis and its testing (following the "canonical history" pointed by Jovanovic, 2008). The emphasis is precisely on empirical proof (and "anomalies"), rather than on the theoretical interpretation of the efficient market hypothesis as an equilibrium concept.

idea can also be found in Campbell (2014)'s piece celebrating Fama, Hansen, and Shiller's Nobel prize.

A first rationale for this "lineage 2" is symmetrical to the rationale for "lineage 1": establishing historical "ancestry" helps the rhetoric of "pre-eminence" of one field over another. However, we would argue that "lineage 2" also relies on additional rationale, namely rational reconstruction. Indeed, putting Muth and rational expectations as the common "ancestor" of both new classical macroeconomics and the efficient market hypothesis reflects the logic of the current benchmark association between the two concepts. As illustrated in the introduction, rational expectations are currently understood as the general principle or assumption that is "applied" to finance (or to macroeconomics). Self-produced narratives of "lineage 2" project this logic into the historical development of the two concepts.

1.4 Independent discoveries

Finally, a few autobiographical accounts support the narrative that there was actually no common ancestry or lineage between rational expectations and the efficient market hypothesis, and that each concept arose independently in the 1960s as an "independent discovery". Furthermore, the two ideas were associated in the very late 1970s.

Young and Hoover (2011) reports a panel discussion about the origins of rational expectations, featuring Lucas, Shiller, Neil Wallace, Dale Mortensen, and Michael Lovell. Young asks to the participants how rational expectations and the efficient market hypothesis were "first connected", since they "seem to have different historical roots" (*ibid.*, 22). Lucas answers the question first, mentioning Merton Miller's opinion (which he seems to endorse) 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 Young and Hoover, 2011, 22)*

Shiller follows up on Lucas's comment to argue that the efficient market hypothesis was well-known (under different names) since the early XXth century, and that the actual breakthrough of the 1970s was rather in the use, within the CRSP, of modern empirical techniques, new data and computers to address the question (*ibid. 22-23)*. Both statements tend therefore to contradict the narrative of an awareness of Muth's work among financial economists in the

1960s, and to support the idea that the efficient market hypothesis was developed independently from rational expectations—furthermore, the rest of the discussion clearly indicates that rational expectations were also developed independently from the efficient market hypothesis.

However, autobiographical accounts also point at the later encounter between the two concepts (and the two communities), taking place at Carnegie (later Carnegie-Mellon)'s Graduate School of Administration (GSIA) at the end of the 1960s. Lucas, in his Nobel autobiography, recalls:

> *During my years there,*[16] *Carnegie-Mellon had a remarkable group of economists interested in dynamics and the formation of expectations. Foremost, of course, was John Muth ... Dick Roll, a student of Eugene Fama's at Chicago, brought the ideas of efficient market theory to GSIA (Lucas, 1997)*

Roll, his own memoires (Roll personal communication, quoted in Sent, 1998, fn 7), corroborates Lucas's above suggestion about his arrival at Carnegie in 1968: a direct dialogue was established then between rational expectations and the efficient market hypothesis.[17] To another celebration, this time for the 25 years of Lucas (1972), Sargent famously recalled: "The late 1960s were good times to be a young macroeconomist" (Sargent, 1995, 2). For Sargent, the flourishing of new developments in macroeconomic modelling resulted from an air "charged with new ideas about distributed lags, costs of adjustments, adaptive and rational expectations, the expectations theory of the term structure, 'efficient market' theories of asset prices, portfolio theories of asset demand, …". In his memoires, Sargent puts therefore the new ideas in finance, including the efficient market hypothesis, among the sources of inspiration for the transformation of macroeconomics at the end of the 1960s. He also emphasizes how then, in the 1970s, macroeconomists were influential in reframing the question of asset pricing (*ibid*., 17-18). In a later interview, Sargent clarifies that I became aware at that time of the work of Fama, Mandelbrot, and Richard Roll, although the topic

[16] After completing his PhD at Chicago in 1966, Lucas was an associate professor at GSIA from 1966 to 1975, when I went back to Chicago.

[17] "In his personal letter dated October 30,1996, Richard Roll, who was also at Carnegie Mellon at that time, remembers many discussions with Lucas, Sargent, Simon, Meltzer, and later others such as Prescott, in which Roll was the advocate of rationality and hence efficient information processing by agents, and the others were generally skeptical." (*ibid*.)

Sargent was interested in was not efficient market hypothesis per se, but rather Lévy stable distributions and infinite variance (Sargent in Sent, 1998, 167).

2. History of macroeconomics, history of rational expectations, and history of finance: The missing links

In recent years, historians of economics produced a significant amount of work uncovering the developments occurred in macroeconomics and finance after World War II. In this section, we discuss existing historical literature about the efficient market hypothesis and finance, rational expectations, and macroeconomics. Our purpose is threefold. First, we point out how the existing historical evidence rules out self-produced narratives claiming a influence of one concept on the other in the 1960s (lineage 1 and 2), therefore supporting the narrative of "independent discovery". Second, we would like to emphasise how the association between rational expectations and the efficient market hypothesis in the 1970s and 1980s—and, more broadly, the interaction between macroeconomics and finance during this period—is still among the blind spots of these (developing) literatures. Finally, our review of current historiography aims at providing the reader with some elements of the broader context for the debates that we analyse in section 3 and 4.

2.1 The history of finance and of the efficient market hypothesis

Historical research about the efficient market hypothesis emphasises how the development of this idea contributed to establishing finance both as an autonomous academic discipline and as a subfield of economics. In the U.S., until the 1960s, finance was taught in business school, mostly by practitioners rather than academics (Mackenzie, 2008; Fourcade and Khurana, 2013). 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 and became firmly established. According to Jovanovic (2008), the breakthrough came with the search for "theoretical explanation" to the observation that asset prices move randomly. And yet, the random character of price changes was already discussed since the XIXth century, especially in the work by financial practitioners such as Jules Regnault, and (more famously) mathematicians such as Louis Bachelier (Jovanovich, 2009). However, the search for

theoretical explanation of this random behaviour gained momentum only in the early 1960s, with the work of economists such as Samuelson and Fama (but not only).[18] Both contributions interpret the randomness of asset prices using an economic framework and some of its distinctive notions—equilibrium, competition or rationality.[19] The study of finance within this framework contributed in anchoring the new field to economics.[20]

Fama (1965) is also the first to employ the expression "efficient market" to designate a theoretical interpretation of randomness. Along with the popularization of the label "efficient market hypothesis", two strains of scholarship developed this analysis during the 1960s: one around Samuelson at MIT and the other around Fama at Chicago.[21] By the end of the 1960s, the efficient market hypothesis was a well-established theory within the field of finance. Historians noted that this breakthrough was not only analytical but also material and institutional. 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, have largely supported the emergence of an econometric research on finance. In the same vein, philanthropic foundations led the reform of business school in the 1950s, in which practitioners had been replaced progressively by economists and statisticians (Fourcade and Khurana, 2013).

In a nutshell, the existing historical literature portrayed the raise of efficient market hypothesis in the 1960s 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. Hence, this historical literature has investigated closely the interaction between financial economics and the rest of the discipline in the 1960s, but the subsequent interactions during the 1970s, and in particular the association with rational expectations, are not fully discussed.[22] While this development has been overlooked, we will illustrate in the next sections that they precisely constitute the logical deepening of the process initiated in the 1960s.

[18] It is part of the outstanding issues in this field of research to determine if actually theoretical explanations were provided or attempted by forerunners of Samuelson and Fama, such for instance Holbrook Working (see Berdell and Choi, 2019).

[19] For a more in-depth analysis on Samuelson and Fama's papers, see Delcey (2019).

[20] The parallel development of the portfolio theory (following Markowitz, 1952) also contributed to this dynamic.

[21] Note that, aside for sharing the same of object of interest, the two "schools" had contradicting viewpoints and methodology (see Jovanovic 2008; Mehrling 2012).

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

2.2 The history of rational expectations

The most important literature investigating the history of rational expectations includes Keuzenkamp (1991), Sent (1998), Young and Darity (2001), Young et al. (2004), and the witness seminar led by Hoover and Young (2011). These contributions cover essentially three issues: (i) the forerunners or "precursors" of Muth; the intellectual and institutional context surrounding Muth's own work; and the dissemination of Muth's paper. We will also address these three issues, in this order, aiming at discussing the following elements: (i) how Samuelson has been discussed by the literature as one potential forerunner of Muth's rational expectations; (ii) how finance and the early work on the efficient market hypothesis played apparently no role in Muth's own formulation of rational expectations; (iii) how Muth's paper had no influence on finance during the 1960s, although it may not have gone unnoticed.

This historical literature managed to build a colorful and diverse list of precursors of Muth. Keuzenkamp (1991) discusses notably Jan Tinbergen's use and labelling of expectations that would be "rational, i.e. consistent with the economic relationships"—a formulation that got then "lost in translation" in a further English version (1933) of the original 1932 paper in German.[23] Moreover, Keuzenkamp refers to a wide set of authors addressing the issue of expectations and coming to formulations close to Muth's one: his list comprehends John M. Keynes, Frederich Hayek, Oskar Morgenstern, Emile Grunberg and Modigliani, but does not mention any financial economist (although Keuzenkamp refers loosely to the interest on expectations by "market analysts"). Young et al. (2004), rather than putting a firm claim about "precursors", emphasises converging patterns of research on expectations from the 1930 till Muth (1961).[24] They also extend Keuzenkamp's list to several other figures, including Erik Lindhal and Samuelson.[25] Young et al. (2004, 20) discuss indeed how Samuelson (1957)'s model of speculation on perishable commodities featured expectations that "as in Muth … are the predictions of the model itself". This paper also anticipated the development of Samuelson's 1965 paper (a nine-year work on a draft called "Axiom of Mathematically Expected Price Formation"); however, Young et al. (2004, 20) are reluctant to call this formulation a "precursor" of Muth's rational expectations, since, they

[23] Young et al. (2004, ch. 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).

[24] For instance, they discuss (ch. 1) how rational expectations have been "implicit" in the concept of equilibrium in game theory since its early development by Morgenstern, John von Neumann, and John Nash.

[25] Research on this issue of "precursors" is still ongoing: recent scholarship pointed out for instance the hypothesis of "ideal expectations" by Working (1949, 1958)—see Berdel and Choi (2019).

argue, Samuelson relies on the (already existing) idea of "perfect foresight".[26] Overall, Young and co-authors seem sceptical on the idea of "precursors" of rational expectations, on the basis that, as also suggested by Kevin Hoover, several economists "came close" to this concept before 1961, but they "never quite capture Muth's definition" (Hoover and Young, 2011, 19).[27]

Concerning the context surrounding Muth's own work, Young et al. (2004, ch. 2 and 3) provided a rich scrutiny of all the existing research programs about expectations ongoing in the U.S. (and the U.K.) during the 1950s. Several older historical accounts (such as, for instance, Sheffrin, 1983, Introduction) already had pointed out how, during this period, Carnegie's GSIA became central to the development of expectations theories (one strain following Herbert Simon's approach around "bounded rationality"; the other strain arising from Muth's own work), ultimately culminating in the publication of the collective volume edited by Holt, Modigliani, Muth and Simon (Holt et al. 1960). Young and co-authors enriched this narrative by identifying several other formal and informal programs (such as the Illinois project led by Modigliani, or the "implicit expectations" program led by Mills), key figures (such as Albert Hart), events (the 1955 Carnegie's conference, establishing Carnegie's lead on the topic), and research communities (e.g. Chicago's "Public Finance and Money" workshop). Their detailed historical investigation is useful to our own investigation on several points. First, the evidence collected by Young and co-authors does not point to coincident research on expectations coming from financial economists or going from any of the groups mentioned above toward finance. In short, no connection seems to have taken place between the two research programs.[28] Nevertheless, an important finding is the fact that not only Carnegie, but also Chicago was an active centre of the research network on expectations. This leaves at least open the *possibility* of discussions and awareness by financial economists located in Chicago (Fama, from 1960; Roberts; …) of the ongoing developments on expectations.

However, such a connection seems to be a mere possibility, especially on the light of Young et al. (2004)'s main finding on the dissemination of Muth's ideas—a finding which is

[26] Also, note that Young et al. (2004) does not connect this contribution to other ongoing developments about the efficient market hypothesis.

[27] Lucas for instance strongly objected 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" (ibid., 15).

[28] Similarly, Sent (1998) reports "ten stories" (or, "hypothesis") that she encountered in her investigation about the development of rational expectations: again, none of this connects neither Muth's work, nor rational expectations in general, to the development of the efficient market hypothesis.

also supported by other historical literature, by bibliometric evidence, and by autobiographical accounts: all along the 1960s, rational expectations were "a solution in search of a problem" (*ibid*., xi). For sure, during the 1960s, Muth's rational expectations were not obscure or unnoticed: besides fitting within a wide network of research on the topic of expectations, Muth's paper was presented several times, including at the 1959 annual meeting of the Econometric Society (*ibid*., ch. 5), and in Chicago (*ibid*. ch. 4; ch. 5, 80). And yet, despite this awareness about Muth's work, the idea of rational expectations was far from being fully appreciated as a breakthrough. Applications of Muth's idea remained scarce;[29] until new classical macroeconomics vindicated him by making of Muth a "father figure" of their approach.[30] To our investigation, this bottom line of historical research on the history of rational expectations is key in ruling out self-produced narratives (lineage 1 and 2) and supporting the thesis of "independent discoveries" of rational expectations and the efficient market hypothesis.

2.3. History of macroeconomics

A substantial amount of recent scholarship investigated the methodological and theoretical turn in macroeconomics in the 1970s. Contributions in the history of macroeconomics tend to focus away from rational expectations *per se*---for the valid reason that, despite being labelled for a while "rational expectations revolution" (following Begg, 1982), this transformation of macroeconomics was not *limited* to the solely issue of expectations. It is widely acknowledged that the research program set in motion by Lucas, Sargent, and their co-authors introduced a breakthrough in the way of addressing aggregate phenomena, which was then developed (though with some substantial methodological and theoretical variations) by the real business cycle (RBC) approach and then by the new Keynesian dynamic stochastic general equilibrium approach (or "new neoclassical synthesis"). Hoover (1988) emphasized the methodological turn and difference between new classical macroeconomics and monetarism; more recently, De Vroey (2016) suggested another perspective on this transformation, qualifying it as the transition from "Marshallian" to "Walrasian" approach to

[29] Bibliometric analysis by Hoover (in Hoover and Young, 2011, 3) confirms this idea through citations patterns: Muth's paper was cited only 29 times during the decade 1960-1969 (vs 171 citations in the following decade), and the expression "rational expectations" was used only in 39 articles (vs. 324 citations in the following decade). Domains of these citations are obviously agricultural economics (since Muth's original paper dealt with the cobweb theorem) and general equilibrium theory (Negishi, 1964; and Radner, 1968; these examples are discussed at length in Young et al., 2004, ch. 5).

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

macroeconomics. These and other works (e.g. Vercelli, 1991; Duarte and Lima, 2012; Backhouse and Boianovski, 2012) converge toward emphasizing the following salient features of the transformation: the implementation of a specific "equilibrium discipline"; a specific understanding of the relation between individual behaviour and aggregate phenomena; distinctive policy implications (around the idea of implementing credible rules for monetary policy).

What about the role played by finance, and more specifically by the literature on the efficient market hypothesis, in the inception of these new approaches to macroeconomics? Conversely to what is claimed by self-produced narratives (lineage 1), there is no evidence of influence of the efficient market hypothesis on the development of new classical macroeconomics, although a wide range of work investigated in detail the different sources of Lucas and coauthors approaches (see in particular Louça, 2004; da Silva, 2013).

What about financial markets and more specifically the use of the efficient market hypothesis within the new approaches to macroeconomics, during and after the 1970s? Historians provided few insights on this specific question. However, a substantial discussion can be found in the early analysis by Hoover (1988, ch. 5). Hoover argues that Fama (1980) provide the influential base for the extension to money and finance of the microfoundational project of new classical macroeconomics. In short, he argues that the efficient market hypothesis (jointly with the Modigliani-Miller theorem) provides ground for a justification of money as a pure mean of transaction rather than a financial asset—a route taken later by Lucas in his "cash in advance" models with Nancy Stokey (Lucas and Stokey, 1987). We can see how a parallel development was taken by the RBC approach, which simply ignore money and monetary policy. Besides Young (2014) provides an interesting insight on the key role of financial economists, and in particular of Fischer Black, in the development of the RBC approach.[31] Black was indeed instrumental in building a dialogue among Edward Prescott, Finn Kydland, John Long and Charles Plosser; moreover, he encouraged them, in his comments to different drafts of Kydland and Prescott (1982), to pursue the development of a "pure, optimal business cycle" without "monetary policy and fooling around with countercyclical fiscal policy" (Black, quoted in Young, 2014, 85).

Hoover's and Young's contributions provide therefore important leads on the association between (broadly) finance and new classical macroeconomics *at the turn of the 1980*, and the consequences *on macroeconomics* of these interdisciplinary dialogue. However,

[31] Mehrling (2012) also refers briefly to Black's work on monetary theory, which actually goes back to the beginning of the 1970s.

neither Young nor Hoover addresses our initial question about *how* and *when* this dialogue actually started, what were its consequences for the development of finance, and more specifically when this dialogue had taken the form of an association between rational expectations and the efficient market hypothesis. We develop our own investigation of this issue in the following two sections.

3. The efficient market hypothesis and rational expectations: The first application to the theories of the term structure

Our investigation of historical literature and self-produced narratives was instrumental in establishing that the association between rational expectations and the efficient market hypothesis has not attested before the 1970s. In this section, we argue—and this is somehow our answer to the question in the title of our paper—that the first explicit association between the two concepts is found in Sargent's "Rational Expectations and the Term Structure of Interest Rates" (1972).[32] We then discuss how this first association rapidly found an echo in Fama (1975)'s reformulation of the efficient market hypothesis.[33]

Sargent's article intended to contribute to a debate on the theories of the term structure, which had been ongoing during the previous decade (Meiselman, 1962; Wood, 1964; Modigliani and Sutch, 1966; 1969, Hamburger and Latta, 1969).[34] Sargent suggests, in his paper, an innovative way of testing the benchmark theory of the term structure, labelled "expectations theory".

The expectations theory simply states that, on a bond market respecting a non-arbitrage condition, current long-term interest rates for bonds should be equivalent to the

[32] Sargent's interest in the topic, as well as his idea of associating, in his analysis, rational expectations and the efficient market hypothesis, is consistent with the historical evidence provided by autobiographical accounts, especially Lucas's claim that Roll "brought" to Carnegie the idea of the efficient market hypothesis in 1968 (cf. supra, 1.4). Influence of Roll on Sargent is also confirmed by Sent's own research (1998, fn 7) and interview with Sargent (ibid., Appendix).

[33] Note that 1975 is also the year of Lucas's transfer from Carnegie to Chicago. These biographical elements (see also fn 31) tend to indicate that the association between rational expectations and the efficient market hypothesis also originated in an active dialogue between the two research communities, helped by tighter institutional connections.

[34] And obviously in the decades before that, going back at least at Hicks (1939). An interesting coincidence is that one of the first use of the expression "rational expectations" (to designate "reasonable" or "consistent" expectations) is to be found in an article by Joan Robinson (1951) discussing precisely the term structure of interest rates.

average of current expectations for future short-term interest rates for bonds. However, the empirical test of this proposition had proven so far to be rather challenging, since obviously current expectations about future interest rates are not observable. Modigliani and Sutch (1966, 1967) suggested formalizing current expectations as distributed (hump-shaped) lags of past interest rates—in short, in line with the "adaptive" expectations approach. However, since the "expectations theory" alone did leave unexplained a significant amount of residual observations,[35] additional theoretical factors were advance, in particular the addition of a "liquidity premium" for long-term bonds.

Sargent's article reframed the testing of the expectations theory of the term structure, by suggesting to test this theory jointly with the assumption that expectations on future interest rates are rational expectations, rather than adaptive. For Sargent, this procedure will constitute a test of the bond market as "an efficient market":

> *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, 1972, 74)*[36]

Since the two "hypotheses" (the expectation theory and rational expectations) have, jointly, one single implication, i.e. that the bond market is "efficient", it becomes somehow straightforward to test this outcome, following the substantial amount of examples developed in the past decade by the literature on the efficient market hypothesis. In short, the two hypotheses would be corroborated if forward interest rates are proven to follow a martingale.[37]

Sargent's results reject the martingale distribution, and therefore the efficiency of the bond market. However, Sargent is reluctant in taking this result as a motive to reject either rational expectations or the expectations theory. In his conclusion, he clarifies how he

[35] Besides, the expectations theory was not able to explain the fact that observed term structures are most often upward-sloping yield curves.

[36] Sargent credits, in a footnote, Roll (1966) and Fama (1970) for devising the expression "efficient market".

[37] Sargent (1972, 75) credits Samuelson (1965) for the martingale model, and Roll (1966) as the first trying to test the distribution of interest rates---indeed, the efficient market hypothesis was mostly tested, along the 1960s, on stock market data. Overall, the paper suggests a substantial engagement with the existing literature on the efficient market hypothesis.

does 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 are "arbitrary", i.e. they do not rely on any theoretical justification (Sargent, 1972, 94). Abandoning rational expectations is equally unacceptable, since it would inconsistent to assume a non-arbitrage condition (implicit in the expectations theory) and expectations that are "non-optimal", i.e. leaving unexploited opportunities for profit (ibid.).

Sargent (1972) impulsed a first comment by Shiller (1972), then a full answer by Modigliani and Shiller (1973)—resulting from Shiller's PhD dissertation "Rational Expectations and the Structure of Interest Rates" (1969-1972, under Modigliani's supervision at MIT).[38] First, these two contributions are notable since they rephrase, for the first time, the idea of rational expectations as "optimal forecast of the future rates" (or return), which constitutes today the canonical formulation employed when associating rational expectations and the efficient market hypothesis (cf. supra, Introduction). Secondly, they quite explicitly accept Sargent's approach to the test of the term structure through a test of the "efficiency" of the bond market—although they criticize the way Sargent conducts such a test in his article. Finally, and most importantly, Shiller and Modigliani take issue with one underlying assumption of Sargent's testing procedure, i.e. that the only "relevant information" for forming expectations on forward rates is the history of past interest rates. They consider, conversely, that an additional factor of crucial importance to the analysis is the expected inflation rate.

While the discussion on the term structure went on (e.g. Cargill, 1975; Hamburger and Platt, 1975), Sargent (1973) took on the issue raised by Shiller and Modigliani on the relation between interest rates and inflation. Most importantly, this aspect of the ongoing debate attracted Fama's contribution, "Short-Term Interest Rates as Predictors of Inflation" (1975). Although not explicitly using the expression "rational expectations", Fama relies here on Sargent, Shiller, and Modigliani's discussion. The paper is also important in rephrasing, for the first time, the efficient market hypothesis into new theoretical terms, consistent with rational expectations (which became then explicit in Fama, 1976).[39]

[38] Note that both Shiller and Sargent had moved to University of Minnesota by 1972: They were therefore colleagues when Sargent's article was published.

[39] Few years later, Fama clearly draws on this 1975 paper to write "Inflation, Output, and Money" and "Stock Returns, Real Activity, Inflation, and Money" (1980a; 1980b), his two "macroeconomics" contributions, where financial markets are integrated to rest of the economy. These two later Fama's papers are those designated by Hoover (1988, ch. 5) as the influential source of the treatment of money and finance in the new classical macroeconomics approach.

4. Stabilization and weaponization

At the turn of the 1970s, the association between the efficient market hypothesis and rational expectations took firmer ground. First, Lucas (1978) reframed the association in rather general terms (disentangling it from the debate about interest rates illustrated in the previous section). Second, the association became widespread both in finance and in macroeconomics. By the first half of the 1980s, the association was then well established and stabilized into its contemporary form. This section explores some key contributions to this stabilization process, and provides some insights about the role played by the association in shaping the developments of the two fields.

Parallel to its stabilization, the association between rational expectations and the efficient market hypothesis became a target. In the second part of this section, we discuss how, in finance, the concept of rational expectations was weaponized against the efficient market hypothesis: by that, we refer to several critical contributions that referred to the assumption of rational expectations to argue against the efficient market hypothesis. It is also important to note that, somehow paradoxically, these criticisms *contributed* to the stabilisation of the association between rational expectations and the efficient market hypothesis: by taking the association as a target, they made it a *benchmark* against which setting the criticisms of the efficient market hypothesis.

4.1 Stabilisation

Lucas "Asset Prices in an Exchange Economy" (1978) was crucial to the stabilisation of the association between rational expectations and the efficient market hypothesis. This is, in our view, not solely related to the wide reception of this paper within the two fields (i.e. its "influence"), which reflects Lucas's newly acquired influential status.[40] Moreover, Lucas's contribution was key in terms of methodology: it reframed the association in "general equilibrium" terms, making the efficient market hypothesis a "theoretical" equilibrium concept, rather than an empirical characterisation of asset prices distribution.

[40] In 1978, Lucas was already a "star" of macroeconomics. His more insightful contributions (Lucas, 1972, 1973, 1976) had already been published and widely circulating, establishing Lucas's reputation in academia and even beyond (Goutsmedt et al. 2019). Therefore, his article on asset prices, published in *Econometrica*, did not go unnoticed; actually it is currently the most cited of Lucas's articles.

Lucas explicitly sets his article as a contribution to finance and to the literature on the efficient market hypothesis. In this respect, he connects both his result and his assumptions to Fama and Muth:[41]

> *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)*

In his model, Lucas discusses the dynamic properties of "market determined" prices of a financial asset, in a single-good pure exchange economy where productivity of firms varies stochastically.[42] In this model economy, financial assets represent "claims on part of the output" produced exogenously (i.e. with no inputs) by one among a large number of heterogeneous firms. Households (which are assumed identical; therefore a single representative household is used) can purchase assets in a "competitive stock market". The problem set by Lucas is then to determine the price sequence for assets and the produced good, assuming that such prices are 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 is that, depending on the specification of the asset-pricing model, equilibrium prices might follow a martingale process, or they might not. In this respect, his conclusion is that the statistical characteristics of a sequence of prices is not a sufficient condition to draw inference on "efficiency":

> *With respect to the random character of stock prices, it is evident that one can construct rigorous economic models in which price series have these characteristics (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 is to be found few lines later, where Lucas clarifies the methodological aspiration of his paper:

[41] Lucas (1978, 1444, fn. 10) also explicitly refers to Samuelson (1965) formulation of the efficient market hypothesis as a martingale.

[42] We might see here a connection with Brock and Mirman (1978) and the development of the real business cycle approach, which seems to have been neglected by the historical literature (in particular Young, 2014).

> *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 is therefore that efficient markets are rather characterized by the equilibrium nature of asset prices (based on rational expectations) than by a particular form of their distribution. We can therefore interpret Lucas's methodological ambition as pushing finance toward formalizing general equilibrium model of asset pricing, rather than pursuing the route of empirical testing of prices distribution. In this respect, Lucas's contribution clearly aims at accelerating the process of "anchoring" finance, as a field of research, into an economics' "discipline of equilibrium"—a process started in the 1960s (cf. *infra*, 2.1).[43] Lucas's call was indeed answered both by supporters of the efficient market hypothesis (Fama, 1980a, 1980b; Cox et al. 1985) and by its opponents (cf. 4.2).[44]

A rapid overview of the literature in finance and macroeconomics around the time of Lucas's article easily confirms the intuition that the association first established by Sargent (1972) was becoming widespread and common; moreover, several new applications arose (for instance, to the determination of the exchange rate: Niehans, 1975; Dornbusch, 1976; Fama, 1984).[45]

At the turn of the 1980s, the approach to macroeconomics set in motion by Lucas and Sargent was maturing. Although controversies and reactions were still ongoing (see for instance De Vroey, ch. 14), Lucas and Sargent were actively engaging with spreading their approach, namely publishing textbooks (Sargent, 1979; Lucas, 1987 [1985]), collecting their works (Lucas, 1981; Lucas and Sargent, 1981), and writing rather "'methodological" papers or "manifestos" (Lucas, 1977, 1980; Lucas and Sargent, 1979). Within this context, two books on macroeconomics, both published in 1983, are of particular interest for our investigation, since they summarize the "rational expectations revolution" in macroeconomics as closely connected to the efficient market hypothesis.

[43] Indeed Lucas's model builds on previous similar contributions, in particular Leroy (1973).

[44] However, most financial economists kept referring to martingales as indissociable from the efficient market hypothesis (e.g. Shiller, 1978, 6).

[45] [NOTE FOR THE SEMINAR: Our intention in a further development of this paper is not to review here all the articles discussing the efficient market hypothesis as a concept equivalent or based on rational expectations. Our plan is to refine a bibliometric analysis showing the increasing joint mention of the two terms. We are currently working on this.]

The first book is Steven Sheffrin's *Rational Expectations* (1983).[46] It was conceived both as a survey of rational expectations literature (both theoretical and empirical) and as an "introduction" to the concept of rational expectations for non-specialist audience—in many universities it is indeed still used today (in his second edition, 1996), as a textbook for graduates. Chapter 4, "Efficient Markets and Rational Expectations", is entirely devoted to survey the literature in finance and in macroeconomics that makes use of the rational expectations hypothesis in the context of the analysis of markets "processing the information efficiently". Sheffrin's exposition, which is mostly based on Lucas (1978), corresponds entirely with the modern formalisation of the association between the two concepts (*cf. supra*).[47]

The second (and more controversial) book contributing to the stabilisation of the association is Frederic Mishkin's *A Rational Expectations Approach to Macroeconomics: Testing Policy Ineffectiveness and Efficient-Markets Models* (1983), which is actually an edited version of a series of papers published by Mishkin between 1978 and 1981.[48] The definition of rational expectations that can be found at very beginning of the book mirrors the definition that can be found 30 years later in his textbook: "[the rational expectations hypothesis] states that expectations reflected in market behaviour will be optimal forecasts using all available information." (Mishkin, 1983, 1) The book was firmly anchored in macroeconomics, and it was actually echoing Lucas and Sargent (1981)'s effort to lay down econometric procedures for testing and estimating rational expectations models (Mishkin, 1983, 1-2). However, Mishkin found worth emphasizing that the "domain of application" of rational expectations had been expanding in the "last few years", coming to include a large set of financial issues (*ibid*., 3); Mishkin openly connects the two domains ("the use of rational expectations (or equivalently, the efficient markets) hypothesis", ibid., 4). In the subsequent chapters, Mishkin highlights "the common elements in procedures" for testing rationality of forecasts, market efficiency, and—more originally—the short run neutrality of aggregate demand policy (*ibid*., 4). It quite evident how the spirit of this analysis, i.e. of a "joint test" of the "efficiency" of market outcomes and of an underlying rational expectations equilibrium, is

[46] Sheffrin held a PhD from MIT (1973-1976) and was supervised by Stanley Fischer; in 1976 he was appointed to University of California, Davis.

[47] Other similar reviews on rational expectations follow the same argument—see for instance Brian Kantor's "Rational Expectations and Economic Thought" published in the *Journal of Economic Literature* (1979). Note that these reviews could be seen as the ancestors of the self-produced narratives described *supra* in 1.2 and 1.3.

[48] Mishkin was also a PhD student of Fischer at MIT (1973-1976), at exactly the same time as Sheffrin [NOTE FOR THE SEMINAR: this connection is still to be investigated]. Mishkin was then appointed assistant professor at University of Chicago in 1976, and stayed in Chicago until 1983, when he joined Columbia.

indebted to Sargent (1972)'s intuition; moreover, it is important to note how, around the same time, the idea of "joint test" became also widespread within the efficient market hypothesis literature.[49]

However, a rather innovative aspect of Mishkin's book lies in his rhetoric, rather than in his analytical content. Indeed, Mishkin attempts to use the empirical literature on the efficient market hypothesis as "an empirical leverage" to support implications about "policy ineffectiveness" of the new classical approach. Indeed, the widespread popular opinion of the time, even among those critical of the efficient market hypothesis, was that "no other proposition in economics … has more solid empirical evidence supporting it than the Efficient Market Hypothesis" (Jensen, 1978, 95). While, around the same period, new classical macroeconomics, and especially its policy implications, were still at a stage where their empirical support was disputed—see for instance Goutsmedt et al. (2019) about the Lucas Critique.

This strategy obviously attracted the harsh criticism of those macroeconomists opposing the new classical approach. In his comment on Mishkin (1978), Modigliani qualifies indeed Mishkin's reasoning as arguing "that current procedures for evaluating policy and forecasting with macroeconometric models are inconsistent with market efficiency in bond and stock markets", a thesis that he bluntly rejects as "unwarranted" and "based on confusion" (Modigliani, 1978). Therefore, the association between efficient market hypothesis and rational expectations also enters into the stage of the debate on policy between new classical macroeconomics and "Keynesians".[50] This remark is important because it also opens an additional path of explanation for the stabilization of the association. Indeed, it could be argued that the association somehow results or support a "strategic" alliance between the two Chicago research groups (the efficient market one and the new classical one) holding similar ideological and policy position against "Keynesians".[51]

[49] We should also note the characterisation of the business cycles as a "random walk" (therefore imitating the tests of the efficient market hypothesis in the 1960s) was also a method brought later by Kydland and Prescott in their RBC approach (based on Hodrick and Prescott, 1980).

[50] Note that this rhetorical strategy was also employed by Lucas in an informal context, namely a talk he gave to a Wall Street financial firm in 1977 (Lucas Archives, Box 39, Folder Mitchell, Hutchins Conference). In that talk, about "New Ideas on Economic Policy", Lucas illustrates his view about money neutrality relying on two examples from the efficient market hypothesis literature (namely stock splits and earnings announcements).

[51] This also consistent with the idea of an ongoing conflict between the "two streams" of research on the efficient market hypothesis (the MIT and Chicago, *cf. supra*, 2.1).

4.2 Weaponization: The efficiency of stock market

It is widely acknowledged that, within finance, the 1980s have been characterized by several challenges against the EMH (e.g. Wang, 2008). These challenges have been both empirical and theoretical: in this subsection, we explore some of them, in order to clarify how the association between the efficient market hypothesis and rational expectations have been used as a rhetorical and as a substantial weapon in these discussions.

At the end of the 1970s, following Fama's reformulation (1976) the association between RE and EMH begins to be explicitly made by financial economists such as Jensen his review of EMH's anomalies (Jensen, 1978, 95):

> *The Efficient Market Hypothesis is an important concept, and it has become increasingly widely accepted since interest in it was reborn in the late 1950's and early 1960's under the rubric of the 'theory of random walks' in the finance literature and 'rational expectations theory' in the mainstream economics literature. (Jensen, 1978, 95)*

As mentioned above, Jensen (1978, 95) famously argued that the efficient market hypothesis was considered as largely corroborated empirically. His literature review introduces a symposium regrouping several contributions testing the possibility of making a systematic profit opportunity in the financial markets---an "anomaly" compared to the efficient market hypothesis prediction. At the time, a challenging literature on EMH may exist but it was view not as a challenge but as refinement for a more "general theory" of efficient market (Jensen, 1978, 96).[52]

Referring explicitly to the literature on the term structure of interest, Shiller (1979) investigates the volatility of long-term interest and concludes that they are too volatile. He argues that the volatility of observed long-term rates is excessive with respect to the volatility of the theoretical "ex post rational rate", that is, the rational expectations of long-term rate. At the same period, published slightly later though, Shiller applies the same procedure to stock market (1981). If the first article already challenge EMH, the second article starts the controversy because it attacks the stock market, the keystone of efficient market proponents

[52] Even a Keynesian economist such as Modigliani, which report in 1979 what he considers as a long-term inefficiency of stock market confesses that: « it is hard to swallow—especially hard for those of us who have been preaching the gospel of efficient markets. It is hard to accept the hypothesis of a long-lasting, systematic mistake in a well-organized market manned by a large force of alert and knowledgeable people. In fact, it can he reported as a contribution to intellectual history that, when the hypothesis first crossed the mind of the senior author some four years ago, it was lightly dismissed as too preposterous to he entertained seriously. » (Modigliani & Cohn, 1979, 35)

(Fama 1965a,b, Fama and al., 1969). Shiller shows that observed volatility of historical stock prices are too high with respect to the theoretical volatility of an "ex-post rational price", that is, the price defines as the rational expectation of the discounted dividend cash flows (also called the "fundamental value", which is basically the rational expectation equilibrium price). Therefore, he argues, that observed high volatilities of long-term rate and stock prices may be explained by the inefficiency of the markets. Shiller (1981) acknowledges that somehow, the excess volatility implies the existence of profit opportunities (423-424) and thus challenge the existing literature on EMH. His goal however is to discuss a different and a "more interesting (from economic standpoint) question: what accounts for movements of real stock prices" (ibid.). Similarly, Summers notes that the findings about above-average profits "are frequently dismissed because they are premised on inefficiencies and hence imply the presence of exploitable excess profit opportunities" (Summers 1986, 591-592). In this methodological paper, Summers argues that former test of efficient market hypothesis "does not establish that financial markets are efficient in the sense of rationally reflecting fundamentals" (ibid.). He gives the example of a model in which a long-term departure from rational expectations of discounted dividend cash flows may not be detected by standard test of the efficient market hypothesis. This new literature associates the EMH with the RE in order to ask a new question of research on the rational valuation of assets prices. Here, the association is used as a weapon to challenge and reformulate the former research program on efficient market hypothesis, which have been largely corroborated by standard tests from the 1960s.

During the same period, rational expectations are also used to challenge the efficient market hypothesis in a rather theoretical way. Grossman and Stiglitz (1976, 1980) famously developed a paradox showing that (i) either the efficient market hypothesis is true, and therefore the financial market cannot achieve their rational expectations equilibrium; or (ii) a rational expectations equilibrium is achieved, but therefore the market is not efficient. Their demonstration relies on a rational expectations model (explicitly inspired from Lucas, 1972) with informed and uninformed agents, facing cost of acquiring information: they show that the efficient market hypothesis requires that information is costless; if information has a non-zero cost, therefore the cost of seeking information should reward informed agent, therefore entailing a non-efficient financial market. The paradox also arise from the fact that when assuming costless information, there is literally no rationale for the very existence financial markets. Grossman and Stiglitz's paradox is perhaps the clearest illustration of what we mean by "weaponization": the association between the two concepts lies at the very same core of their criticism of the efficient market hypothesis. Following a very similar line of reasoning,

the literature on "rational bubbles" aims at showing that asset prices' departures from their equilibrium values arise within frameworks assuming rational expectations (Blanchard 1979, Blanchard and Watson, 1984; Tirole, 1982, 1985). Interestingly, this literature emphasises that the departure from equilibrium values (or fundamental values), and thus, inefficiency, may be consistent with rational behaviour. This literature is however more interested by formalizing rigorously bubbles than defending any assumption on rationality. Blanchard and Watson (1984, 80) stresses for instance: "it is hard to analyse rational bubbles. It would be much harder to deal with irrational bubbles".

Finally, let us emphasise that the theoretical and empirical challenges to the efficient market hypothesis provided a crucial impulsion to the rise of behavioural finance (in particular Shiller, 1984; Thaler and Bondt, 1985). Paradoxically, it is the anchoring of EMH in an explicit rational framework which has led to the rise of behavioural finance. Another common pattern of this association is that it has been made by outsiders of financial economics: scholars such as Shiller, Blanchard, Summers, Tirole, Stiglitz or Grossman have been formed in economics departments in the 1970s. It is interesting to note that most of these non-financial economists have made their PhD in the Keynesian environment of MIT. Hence, while we saw in section 3 that the association have been a way to establish the new classical view in macro against the Keynesians, we saw here that the association serves to challenge the Chicago's view on EMH. These oppositions should not be resumed, however, to an ideological opposition between a Chicago's pro market view and a MIT's Keynesian view. Through this association we observe also a rather conflictual interaction between fields with different methods and research questions (Summers, 1985; Ross, 1987). If financial economists also re-appropriate themselves the rational expectations framework, it is mainly non-financial opponents to efficient market hypothesis who stabilized the association.

Conclusion

This contribution to the history of macroeconomics and the history of finance illustrated how the association between the efficient market hypothesis and rational expectations emerged in the early 1970s within the debate about the theories of the term structure. We discussed how the progressive stabilization of the two concepts (as related or equivalent equilibrium concepts) was achieved by the end of the 1970s and became widespread in the 1980s. We suggested the different outcomes of this association in the two fields, in particular how the use

of rational expectations deepened the links between finance and economics (through a common "equilibrium discipline") and how referring to the efficient market hypothesis provided theoretical and empirical support for the development of the new classical macroeconomics approach to money and financial markets. Finally, we analysed how the association between rational expectations and the efficient market hypothesis became a benchmark also for those that were criticizing these notions, particularly the criticists of the efficient market hypothesis in the 1980s. Therefore, our investigation has left unexplored the evolution of this association during the following three decades up to today, and, more critically, the evolution of this association during the last decade, i.e. since the events of the global financial crisis in 2008. This further research would obviously benefit from the historical perspective provided by this paper on the interaction between finance and macroeconomics.

References

Backhouse, Roger E., and Mauro Boianovsky. 2012. *Transforming Modern Macroeconomics: Exploring Disequilibrium Microfoundations, 1956–2003*. Cambridge: Cambridge University Press.

Begg, David. 1982. The Rational Expectations Revolution. *Economic Outlook*, 6(9): 23-30.

Berdell, John, and Jin Wook Choi. 2018. Clashing Analyses of Speculation and the Early Regulation of US Futures Markets. *Journal of the History of Economic Thought*, 40(4), 539-560.

Bernstein, Peter L. 1993. *Capital Ideas: The Improbable Origins of Modern Wall Street*. New York: Simon and Schuster.

Blake, David. 2001. *Financial Market Analysis*. 3rd edition. New York: John Wiley & Sons.

Blanchard, Olivier J. 1979. Speculative Bubbles, Crashes and Rational Expectations. *Economics Letters*, 3(4): 387-389.

Blanchard, Olivier J., and Watson, Mark W. 1984. Bulles, anticipations rationnelles et marchés financiers. *Annales de l'INSEE*, 1984: 79-100.

Blanchard, Olivier J. 2016. *Macroeconomics.* 7th Global edition. London: Pearson.

Brock, William A., 1979, An Integration of Stochastic Growth Theory and the Theory of Finance, Part I: The Growth Model. In Jerry Green and J. Scheinkman (eds), *General Equilibrium, Growth and Trade*, New York: Academic Press.

Burda, Michael and Charles Wyplosz. 2013. *Macroeconomics: A European Text.* 6th edition. Oxford: Oxford University Press.

Burton, Maureen, Reynold F. Nesiba, and Bruce Brown. 2010. *An Introduction to Financial Markets and Institutions*. 3rd edition. London: Routledge.

Campbell, J. Y. 2014. Empirical Asset Pricing: Eugene Fama, Lars Peter Hansen, and Robert Shiller. *The Scandinavian Journal of Economics*, 116(3): 593-634.

Cargill, Thomas F. 1975. The Term Structure of Interest Rates: A Test of the Expectations Hypothesis. *The Journal of Finance*, 30(3): 761-771.

Cox, John C., Jonathan E. Ingersoll, and Stephen Ross. 1985. An Intertemporal General Equilibrium Model of Asset Prices. *Econometrica*, 53(2): 363-384.

da Silva, Danilo Freitas Ramalho. 2017. Lucas's Research in the Late 1960s and the Natural Rate of Unemployment. *History of Political Economy*, 49(1): 137-159.

De Bondt, Werner F., and Richard Thaler. 1985. Does the Stock Market Overreact? *The Journal of Finance*, 40(3): 793-805.

De Vroey, Michel. 2016. *A History of Modern Macroeconomics from Keynes to Lucas and Beyond*. Cambridge: Cambridge University Press.

Dimand, Robert W. 2007. Irving Fisher and Financial Economics: The Equity Premium Puzzle, the Predictability of Stock Prices, and Intertemporal Allocation under Risk. *Journal of the History of Economic Thought*, 29(2): 153-166.

Dornbusch, Rudiger. 1976. Expectations and Exchange Rate Dynamics. *Journal of Political Economy*, 84(6): 1161-1176.

Duarte, Pedro Garcia and Lima, Gilberto Tadeu (eds). 2012. *Microfoundations Reconsidered. The Relationship of Micro and Macroeconomics in Historical Perspective*. Cheltenham: Edward Elgar.

Fama, Eugene F. 1965. The Behavior of Stock-Market Prices. *The Journal of Business*, 38(1): 34-105.

Fama, Eugene F. 1970. Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance*, 25(2): 383-417.

Fama, Eugene F. 1975. Short-Term Interest Rates as Predictors of Inflation. *American Economic Review*, 65(3): 269-282.

Fama, Eugene F. 1976. *Foundations of Finance: Portfolio Decisions and Securities Prices*. Basic Books.

Fama, Eugene F. 1980. Banking in the Theory of Finance. *Journal of Monetary Economics*, 6(1): 39-57.

Fama, Eugene F. 1981. Stock Returns, Real Activity, Inflation, and Money. *American Economic Review*, 71(4): 545-565.

Fama, Eugene F. 1984. Forward and Spot Exchange Rates. *Journal of Monetary Economics*, 14(3): 319-338.

Fama, Eugene F. 1990 [1981]. Stock Returns, Expected Returns, and Real Activity. *The Journal of Finance*, 45(4): 1089-1108.

Fama, Eugene F. 1991. Efficient Capital Markets: II. *The Journal of Finance*, 46(5): 1575-1617.

Fischer, Stanley. 1996. Robert Lucas's Nobel Memorial Prize. *The Scandinavian Journal of Economics*, *98*(1): 11-31.

Fischer, Stanley. 2008. New classical macroeconomics. In Steven N. Durlauf, and Lawrence E. Blume (eds), *The New Palgrave Dictionary of Economics*. Basingstoke: Palgrave Macmillan.

Fourcade, Marion, and Rakesh Khurana. 2013. From Social Control to Financial Economics: The Linked Ecologies of Economics and Business in Twentieth Century America. *Theory and Society*, 42(2): 121-159.

Giraud, Yann. 2018. Textbooks in the Historiography of Recent Economics, In Till Düppe and E. Roy Weintraub (eds), *A Contemporary Historiography of Economics*, Oxon: Routledge, 137-154.

Goutsmedt, Aurélien, Erich Pinzón-Fuchs, Matthieu Renault, and Francesco Sergi. 2019. Reacting to the Lucas Critique: The Keynesians' Replies. *History of Political Economy,* 51(3): 533-556.

Goutsmedt, Aurélien, Danielle Guizzo, and Francesco Sergi. 2019. An Agenda without a Plan: Robert E. Lucas's Trajectory through the Public Debate. *Œconomia – History, Methodology and Philosophy*, forthcoming.

Grossman, Sandford J., and Joseph E. Stiglitz. 1976. Information and Competitive Price Systems. *American Economic Review*, 68(2): 246-253.

Grossman, Sanford J., and Joseph E. Stiglitz. 1980. On the Impossibility of Informationally Efficient Markets. *American Economic Review*, 70(3), 393-408.

Hall, Robert E., 1996. Robert Lucas, Recipient of the 1995 Nobel Memorial Prize in Economics. *The Scandinavian Journal of Economics*, 98(1): 33–48.

Hamburger, Michael J., and Cynthia Latta. 1969. The Term Structure of Interest Rates: Some Additional Evidence. *Journal of Money, Credit and Banking*, 1(1): 71-83.

Hamburger, Michael J., and Elliot N. Platt. 1975. The Expectations Hypothesis and the Efficiency of the Treasury Bill Market. *The Review of Economics and Statistics*, 57(2): 190-199.

Hicks, John. 1939. *Value and Capital*. Oxford: Claredon Press.

Hodrick, Robert J. and Prescott, Edward C. 1978. Postwar U.S. BusinessCycles: A Descriptive Empirical Investigation. *Carnegie-Mellon Working Paper*, 4-78-79. Published in 1997, *Journal of Money, Credit and Banking*, 29(1): 1-16.

Holt, C. C., Franco Modigliani, John F. Muth, abnd Herbert A. Simon. 1960. *Production Planning, Inventories, and Workforce*. Englewood Cliffs: Prentice-Hall.

Hoover, Kevin D. 1988. *The New Classical Macroeconomics. A Sceptical Inquiry*. Oxford: Basil Blackwell.

Hoover, Kevin D., and Warren Young. 2011. Rational Expectations: Retrospect and Prospect.

Economic Research Initiatives at Duke (ERID), Working Paper.

Howells, Peter, and Keith Bain. 2010. *The Economics of Money, Banking and Finance*. 6th edition. Prentice Hall.

Kantor, Brian. 1979. Rational Expectations and Economic Thought. *Journal of Economic Literature*, 17(4): 1422-1441.

Keuzenkamp, Hugo A. 1991. A Precursor to Muth: Tinbergen's 1932 Model of Rational Expectations. *The Economic Journal*, 101(408): 1245-1253.

Kydland, Finn E. and Edward C. Prescott. 1982. Time to Build and Aggregate Fluctuations. *Econometrica*, 50(6): 1345–1370.

Jensen, Michael C. 1978. Some Anomalous Evidence Regarding Market Efficiency. *Journal of Financial Economics*, 6(2/3): 95-101.

Jovanovic, Franck. 2008. The Construction of the Canonical History of Financial Economics. *History of Political Economy*, 40(2), 213-242.

Jovanovic, Franck. 2009. Le modèle de marche aléatoire dans l'économie financière de 1863 à 1976. *Revue d'histoire des sciences humaines*, 2009(1): 51-78.

LeRoy, Stephen F. 1973. Risk Aversion and the Martingale Property of Stock Prices. *International Economic Review*, 14(2): 436-446.

Lo, Andrew. 2008. Efficient Market Hypothesis. In Steven N. Durlauf, and Lawrence E. Blume (eds), *The New Palgrave Dictionary of Economics*. Basingstoke: Palgrave Macmillan.

Long, John B. and Charles I. Plosser. 1983. Real Business Cycles. *Journal of Political Economy*, 91(1): 39–69.

Louçã, Francisco. 2004. Swinging All the Way: The Education of Doctor Lucas and Foes. *History of Political Economy*, 36(4): 689–735.

Lucas, Robert E. 1972. Expectations and the Neutrality of Money. *Journal of Economic Theory*, 4(2): 103–124.

Lucas, Robert E. 1976. Econometric Policy Evaluation: A Critique. *Carnegie-Rochester Conference Series on Public Policy*, 1:19–46.

Lucas, Robert E., 1977. Understanding Business Cycles. *Carnegie-Rochester Conference Series on Public Policy*, *5*: 7-29.

Lucas, Robert E. 1978. Asset Prices in an Exchange Economy. *Econometrica*, 48(6): 1429-1445.

Lucas, Robert E. 1980. Methods and Problems in Business Cycle Theory. *Journal of Money, Credit and Banking*, *12*(4): 696–715.

Lucas, Robert E. 1981. *Studies in Business Cycle Theory*. Cambridge, Mass.: MIT Press.

Lucas, Robert E. 1987. *Models of Business Cycles*. Oxford: Basil Blackwell.

Lucas 1996. Robert E. Lucas Jr. Biographical. In Tore Frängsmyr (ed.), *The Nobel Prizes*, Stockholm: Nobel Foundation, available at

https://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1995/lucas-bio.html

Lucas, Robert E. and Thomas J. Sargent. 1978. After Keynesian Macroeconomics. In *After the Phillips Curve: Persistence of High Inflation and High Unemployment*, Boston, Mass: Federal Reserve Bank of Boston, 49-72.

Lucas, Robert E. and Thomas J. Sargent. 1981. *Rational Expectations and Econometric Practice*. London: George Allen and Unwin Ltd.

Lucas, Robert E. and Stokey, Nancy L. 1987. Money and Interest in a Cash-in-Advance Economy. *Econometrica*, 55(3): 491–513.

MacKenzie, Donald. 2008. *An Engine, not a Camera: How Financial Models Shape Markets*. Cambridge, MA: MIT Press.

Malkiel, Burton G. 1987. Efficient Market Hypothesis. In Steven N. Durlauf, and Lawrence E. Blume (eds), *The New Palgrave Dictionary of Economics*. Basingstoke: Palgrave Macmillan

Malkiel, Burton G. 2003. The Efficient Market Hypothesis and its Critics. *Journal of Economic Perspectives*, 17(1): 59-82.

Markowitz, Harry M. 1952. Portfolio Selection. *The Journal of Finance*, 7(1): 77-91.

Meiselman, David. 1962. *The Term Structure of Interest Rates*. Englewood Cliffs: Prentice-Hall.

Mehrling, Perry. 2012. *Fischer Black and the Revolutionary Idea of Finance.* New York: Wiley.

Merton, Robert C. 2006. Paul Samuelson and Financial Economics. *The American Economist*, 50(2): 9-31.

Mishkin, F. S. (1978). Efficient-Markets Theory: Implications for Monetary Policy. *Brookings Papers on Economic Activity*, 1978(3), 707-752.

Mishkin, Frederic S. 1983. *A Rational Expectations Approach to Macroeconometrics. Testing Policy Ineffectiveness and Efficient-Market Models*. Chicago: Chicago University Press.

Mishkin, Frederic S. 2016. *The Economics of Money, Banking, and Financial Markets*. Eleventh Edition (Global Edition). Harlow: Pearson.

Modigliani, Franco. 1978. [Efficient-Markets Theory: Implications for Monetary Policy]. Comments and Discussion. *Brookings Papers on Economic Activity* 1978(3): 753-768.

Modigliani, Franco and Richard Sutch. 1966. Innovations in Interest Rate Policy. *American Economic Review*, 56(1/2): 178-197.

Modigliani, Franco and Richard Sutch. 1969. The Term Structure of Interest Rates: A Reexamination of the Evidence: Reply. *Journal of Money, Credit and Banking*, 1(1): 112-120.

Modigliani, Franco and Robert J. Shiller. 1973. Inflation, Rational Expectations and the Term Structure of Interest Rates. *Economica*, 40(157), 12-43.

Modigliani, Franco, and Richard A. Cohn. 1979. Inflation, Rational Valuation and the Market. *Financial Analysts Journal*, 35(2): 24-44.

Muth, John F. 1961. Rational Expectations and the Theory of PriceMovements. *Econometrica*, 29(6): 315–335.

Negishi, Takashi. 1964. Stability and Rationality of Extrapolative Expectations. *Econometrica*, 32(4): 649-651.

Niehans, Juerge. 1975. Some Doubts about the Efficacy of Monetary Policy under Flexible Exchange Rates. *Journal of International Economics*, 5(3): 275-281.

Poterba, James M., and Lawrence H. Summers. 1988. Mean Reversion in Stock Prices: Evidence and Implications. *Journal of Financial Economics*, 22(1): 27-59.

Robinson, Joan. 1951. The Rate of Interest. *Econometrica*, 19(2): 92-111.

Roll, Richard. 1966. The Efficient Market Model Applied to U.S. Treasury Bill Rates. PhD Dissertation, University of Chicago.

Ross, Stephen. 1987. The Interrelations of Finance and Economics: Theoretical Perspectives. *American Economic Review*, 77(2): 29-34.

Ross, Stephen. Finance. In Steven N. Durlauf, and Lawrence E. Blume (eds), *The New Palgrave Dictionary of Economics*. Basingstoke: Palgrave Macmillan.

Samuelson, Paul A. 1957. Intertemporal Price Equilibrium: A Prologue to the Theory of Speculation. *Weltwirtschaftliches Archiv*, 181-221.

Samuelson, Paul A. 1965. Proof that Properly Anticipated Prices Fluctuate Randomly, *Industrial Management Review*, 6: 41-49.

Sargent, Thomas J. 1972. Rational Expectations and the Term Structure of Interest Rates. *Journal of Money, Credit and Banking*, 4(1), 74-97.

Sargent, Thomas J. 1973. Interest Rates and Prices in the Long Run: A Study of the Gibson Paradox. *Journal of Money, Credit and Banking*, 5(1): 385-449.

Sargent, Thomas J. 1979. *Macroeconomic Theory*. New York: Academic Press.

Sargent, Thomas J. 2008. Rational Expectations. In Steven N. Durlauf, and Lawrence E. Blume (eds), *The New Palgrave Dictionary of Economics*. Basingstoke: Palgrave Macmillan.

Sent, Esther-Mirjam. 1998. *The Evolving Rationality of Rational Expectations. An Assessment of Thomas Sargent's Achievements*. Cambridge: Cambridge University Press.

Sergi, Francesco. 2019. The Standard Narrative about DSGE Models in Central Banks' Technical Reports. Unpublished.

Sheffrin, Steven M. 1983. *Rational Expectations*. Cambridge: Cambridge University Press.

Shiller, Robert J. 1972. Rational Expectations and the Term Structure of Interest Rates: Comment. *Journal of Money, Credit and Banking*, 5(3): 856-860.

Shiller, Robert J. 1978. Rational Expectations and the Dynamic Structure of Macroeconomic Models: A Critical Review. *Journal of Monetary Economics*, 4(1): 1-44.

Shiller, Robert J. 1979. The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure. *Journal of Political Economy*, 87(6): 1190-1219.

Shiller, Robert J. 1981. The Use of Volatility Measures in Assessing Market Efficiency. The *Journal of Finance*, 36(2), 291-304.

Tinbergen, Jan. 1933. The Notions of Horizon and Expectancy in Dynamic Economics. *Econometrica*, 1(3): 247-264.

Tirole, Jean. 1982. On the Possibility of Speculation under Rational Expectations. *Econometrica*, 50(5): 1163-1181.

Tirole, Jean. 1985. Asset Bubbles and Overlapping Generations. *Econometrica*, 53(6): 1499-1528.

Vercelli, Alessandro. 1991. *Methodological Foundations of Macroeconomics: Keynes and Lucas*. Cambridge: Cambridge University Press.

Vuillemey, G. 2013. Sur le statut épistémologique de l'hypothèse d'efficience des marchés. *Revue de philosophie economique*, 14(2): 93-118.

Walter, Christian. 2006. Les martingales sur les marchés financiers. *Revue de synthèse*, 127(2), 379-391.

Wang, Y. 2008. Finance (New Developments). In Steven N. Durlauf, and Lawrence E. Blume (eds), *The New Palgrave Dictionary of Economics*. Basingstoke: Palgrave Macmillan.

Wood, John. The Expectations Hypothesis, the Yield Curve and Monetary Policy. Quarterly Journal of Economics, 78(3):457-470.

Woodford, Michael. 1999. Revolution and Evolution in Twentieth-Century Macroeconomics. Communication for the conference on "Frontiers of the Mind in the Twenty-First Century", Library of Congress, June 14-18 1999, available at http://www.columbia.edu/~mw2230/macro20C.pdf [retrieved 10/01/19].

Working, Hoolbrook. 1949. The Investigation of Economic Expectations. *American Economic Review*, 39(3): 150-166.

Working, Hoolbrook. 1958. A Theory of Anticipatory Prices. *American Economic Review*, 48(2): 188-199.

Young, Warren. 2014. *Real Business Cycle Models in Economics*. London: Routledge.

Young, Warren and William A. Darity. 2001. The Early History of Rational and Implicit Expectations. *History of Political Economy*, 33(4): 773-813.

Young, Warren, William A. Darity, and Robert Leeson. 2004. *Economics, Economists and Expectations*. London: Routledge.