

# Evolution of expectations models in economic thought

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**Abstract.** Inflation expectations have been of prime interest for policymakers and researchers for decades. In 2023, when high inflation is one of the biggest challenges facing the world, economists must give them due weight. This article provides a systematic chronological treatment of the main approaches to expectations formation modelling in macroeconomics. While a number of surveys with focus on separate models are available, a full treatise (as per the author's research) has been missing. This paper aims to fill the gaps. However, despite being exhaustive, it does not pretend to be coping with all contributions ever developed. The author has tried to present the topic in a way that is accessible and useful both to graduate students who encounter the subject for the first time and practitioners with previous knowledge who need a systematic treatment of the subject. The article starts with a general overview what are expectations and, in particular, inflation expectations, and why do they matter. This is followed by a chronological presentation of the main expectations models and a discussion of the prerequisites to appear, their implications and significance to economic thought, as well as, criticism. Finally, the author offers some perspectives and conclusions on the subject.

## 1 Introduction

"Each man possesses opinions about the future, which go by the general name of expectations". (Plato, *Laws*, 644c, 360 BC)

As Plato wrote, everyone forms expectations. It is an innate process that starts from an early age. Before babies learn to talk, they form expectations based on their experience and show emotions when the event occurs or fails to occur – respectively smile or cry. The main role of expectations is to help us form a general picture of what could happen in the more or less near future.

Expectations are also what differentiates economics from other sciences. They are in the basis of almost every theory. "In consumption theory, the paradigm life cycle and permanent income approaches stress the role of expected future incomes. In investment decisions present value calculations are conditional on expected future prices and sales. Equity prices, interest rates, and exchange rates all clearly depend on expected future prices [1]".

However, there is one big challenge that we are facing the last two years and for which expectations particularly matter – the global inflation. The Covid-19 pandemic drove a shift

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from services to goods and increased the demand for housing. It also caused vulnerabilities in supply chains. All these, in combination with Russia's invasion of Ukraine in February 2022, have driven inflation exceptionally high. High inflation is concerning for households because it affects their incomes and respectively spendings. Businesses, especially small ones, are also exposed to inflation pressure. Here comes the role of inflation expectations which is way beyond representing the rate at which people expect prices to rise in the future. Inflation expectations affect the effectiveness of fiscal and monetary policy, as well as realized inflation.

Unfortunately, there is no convergency on how they are being formed. In the next lines we will survey the chronology of expectations models – how they have evolved with the time, what were the prerequisites for this change, what have been the implications of the models for economic thought and, of course, we will not surpass the criticism.

## **2 Expectations formation models in macroeconomics**

The earliest references to economic expectations or forecasts date to the ancient Greek philosophers [2]. In *Politics* (1259a), Aristotle recounts an anecdote concerning Thales of Miletus (c. 636–c. 546 B.C.) who forecasted a great olive harvest and placed deposits for the use of all the olive presses in Chios and Miletus. When the time for gathering the crop came, Thales made a large amount of money letting out the presses at high rates.

Stories illustrating the importance of expectations in economic decision making can also be found in the Old Testament [2]. One such story, for example, is about Joseph who on behalf of the Pharaoh took actions to store grain from years of good harvest in order to use it during years of famine. Although, references to economic expectations date back as long as ancient times, systematic economic theories or analyses in which expectations play a major role began as early as the beginning of the 19th century [2].

### **2.1 Traditional expectations models**

The theoretical importance of expectations played an increasing role throughout the 19th century. They were already present during the first half of this century especially in the discussions in France and in Great Britain of empirical issues related to money, credit and public policy however [3].

Two expectations concepts have been widely used in this early economics literature. These are the concept of static or naïve expectations and its more advanced variation, the concept of adaptive expectations.

“The static expectations assumption states that people expect the value of an economic variable next period to be equal to the current value of this variable.” [4]

“Adaptive expectations assumption merely extrapolates the concept of static expectations—it suggests that economic agents expect the inflation rate to be equal to the weighted average of the inflation rate in the past few periods.” [4]

The early developments though, were partial and related to specific observed mechanisms and phenomena. Evans and Honkapohja (2001) [2] attribute pioneers' role to systematic expectations analyses to Henry Thornton and his treatment of paper credit, published in 1802, and Émile Cheysson's 1887 formulation of a framework which had features of the “cobweb” cycle. Arena et al. (2021) [3] consider as real game changers the French Clément Juglar and Léon Walras.

We will begin the review with the notion of [3]. Juglar, who they mention, analysed long series of banking statistics (discounts, metallic reserves, circulation of banknotes, deposits) and in 1862 authored the theory of the business cycle. He tried to use changing periodicity to

characterize expectations but failed to justify them theoretically. On the other hand, Walras, in 1874 built a theory of General economic equilibrium referring to static expectations. However, there are still discussions whether this equilibrium was a static one or a rest point of a genuinely dynamic process. After Juglar and Walras, Alfred Marshall was credited with the notion of ‘static expectations’ of prices but his distinction between very short, short and long periods led to a more substantial reflection of various types of expectations and their relations with different equilibria [3].

Going back to Émile Cheysson, in 1887 he formulated a framework which had features of the “cobweb” cycle [2]. The cobweb model is one of the oldest and simplest models of economic dynamics. It is also known as dynamic stability with lagged adjustment. Whenever demand or supply changes, equilibrium also changes. There is a time lag between a change in price and appropriate adjustment in supply in response to it. [5] In 1928 and 1930, the model has also been implied in an earlier article by an agricultural economist Arthur Hanau [6]. However, it was not until 1930 when the three economists Henry Schultz, Umberto Ricci, and Jan Tinbergen - independently discovered the mechanism of the cobweb and published articles reporting their results [6]. The model became popular after Ezekiel (1938) [7]. During this period, the mathematical form of the cobweb model became associated with linear difference and differential equations. This was necessary in order to establish a soluble mathematical model. This trait of the cobweb though, was considered “naïve in the sense that producers permanently hold the same price expectation even though this expectation is never satisfied by market price behavior” [6].

When economic agents form their expectations on the basis that nothing in the economy changes (i.e. on static expectations models), they ignore the fact that inflation can change. This belief is far from reality, thus, the framework had to evolve and adaptive expectations models took over the floor.

In parallel with the cobweb discovery, in the years between 1927 and 1939, a number of Swedish economists explored concepts of macroeconomic dynamics, in which the interchangeable notions of “anticipations” and “expectations” played a key role. They developed a variety of approaches to equilibrium theory and disequilibrium sequence analysis; and they used the twin notion of *ex ante* and *ex post* to set the focus on the frustration and adaptation of expectations that agents form in interdependent markets. Bertil Ohlin grouped these economists, including himself, under the label “Stockholm School of economic thought”. However, most of his colleagues were not comfortable with the school label, as they tended to emphasize the differences between them more than what they had in common [8]. See Trautwein (2021) [8] for a detailed treatise of the Stockholm School.

The second half of the 1930s was also marked by the iconic General Theory by Keynes. According to Evans and Honkapohja (2015) [1] Keynes stressed the central role of expectations for the determination of output and employment but did not have an explicit model of how expectations are formed. Arena and Nasica (2021) [9] on the other hand, leave a hint that Keynes was actually ahead of his time. For him simple extrapolative or adaptive expectations, apart in the cases of certainty or very short periods, were incompatible with an economic analysis which attributes a major importance to future and expected economic change, in the short as well as the long period. A specific methodological conception open to the help of philosophy and psychology was therefore necessary for Keynes to explain decision making in the real world.

Leaving Keynes aside and going back to adaptive expectations, we shall mention that Evans and Honkapohja (2001) [2] trace them to Fisher, respectively to the named after him “Fisher effect” and the “Gibson paradox”. Humphrey (1983) [10] on the other hand, has found that similar idea was already existent before that. In the 1740s, William Douglass used early version of “Fisher effect” to explain how the overissue of colonial currency and the depreciation of paper money raised the yield on loans denominated in paper compared to the

yield on loans denominated in silver coin. After him, Humphrey (1983) [10] considers Henry Thornton to have used the same notion in 1811 to explain how an inflation premium was incorporated into and generated a rise in British interest rates during the Napoleonic wars. Followed by Jacob de Haas who in 1889 employed the real/nominal rate idea to account for the “third (inflationary) element” in interest rates, the other two being a reward for capital and a payment for risk. And in 1890, Alfred Marshall cited the interest-inflation relationship as the key component in his theory of the transmission mechanism through which variations in the value of money generate trade cycles. The relationship achieved its classic exposition in Irving Fisher’s *Appreciation and Interest* (1896) [10].

Fisher on the other hand, had influence on Friedman both indirect through the Chicago School and direct - in the 1960s, Friedman adopted the Fisher effect and Fisher's empirical approach to inflationary expectations into his analysis [11]. When he first addressed the expectations issue in his work on macroeconomic dynamics, Friedman actually considered static expectations. In the mid-1960s his anticipationist critique of the Phillips curve led Friedman to place at the centre of the analysis the idea that private agents progressively adjust their forecasts to a new informational environment, i.e., they form adaptive expectations [12]. David Laidler (2006) [13] in his essay “Milton Friedman and the Evolution of Macroeconomics”, by citing Philip Cagan (2000) [14], “accuses” Friedman to have picked the idea of adaptive expectations in 1952 from conversations with A. W. Phillips. It was then, under Friedman’s influence, that the idea was successfully deployed to proxy inflation expectations by Phillip Cagan in his study of hyperinflations in 1956.

Cagan definitely left a mark in adaptive expectations history with his famous model (on his name). It consists of two equations, one which describes individuals’ demand for money and another which describes the evolution of inflation expectations over time. The second part of the Cagan model is that he assumed adaptive expectations, meaning that expected inflation is a weighted average of current inflation and past expectations of inflation [15]. One of the important messages that economists take away from Cagan is the need for individuals’ inflation expectations to be ‘anchored’.

Begg (1982) [16] attributes adaptive expectations model not only to Cagan but to Nerlove as well. The work of Marc Nerlove in 1958 started an econometric tradition in estimating agricultural supply relations. It had greater intuitive appeal than the pre-Nerlovian models because it allowed people to revise their notion of “normal” price in proportion to the difference between current price and their previous idea of a “normal” price. Moreover, it appeared less naive because it allowed for adjustment of expectations.

In short, adaptive expectations hypothesis has long history, and became and remained popular until rational expectations models because in its error learning form it looked like classical updating of an expectation based on new information and it was empirically easy to employ. However, it was not surpassed by criticism. In the actual world, previous behaviour is just one of many variables that affect present and future actions. If inflation is trending upward or lower, adaptive expectations are constrained.

## **2.2 Rational expectations**

“By the 1960s, the models used in macroeconomics described the aggregate economy as consisting of a system of equations: one equation to describe consumption, one to describe investment, one to describe money demand, and so on. Each of these equations was loosely thought of as arising from a deeper formulation of individual or firm decision making. This approach was attractive because the models were mathematically explicit and the parameters of the equations could be estimated using the powerful econometric procedures that had been developed... At the same time, the desirability of making specific the relationship between macroeconomic models and microeconomic theory was widely recognized.” [17].

The economic theory had to evolve. Chari (1999) [17] comments that there are two fundamental postulates which stayed at the base of the evolved framework. The first is that individuals act purposefully to achieve the ends they seek and the second is that since outcomes depend upon the actions of everyone in society, agents must form expectations about the actions of others and, indeed, expectations about the expectations of others, and so on. This feature can be captured by the notion of equilibrium. The thinking of equilibrium as a rest point in the space of decision rules appeared in the work of John Nash (1950) [18] in game theory and the work of Kenneth Arrow (1951) [19] and Gerard Debreu (1959) [20] in the theory of competitive equilibrium.

It was in 1961 when John Muth outlined the new theory of expectations which aimed to overcome the flaws of the previous theories – the rational expectations hypothesis.

For Muth, individuals are rational and use all available information to make unbiased, informed predictions about the future. This means that individuals do not make systematic errors in their predictions and that their predictions are not biased by past errors. In addition to the criticism of adaptive expectations, Muth (1961) [21] criticizes also the ex-ante analysis of the Stockholm school. He finds it limited as it is non-explanatory of the genesis of expectations. Moreover, for Muth “it is often necessary to make sensible predictions about the way expectations would change when either the amount of available information or the structure of the system is changed”. Last but not least, he motivates the need for a new theory from statistical perspective – “parameter estimates are likely to be seriously biased towards zero if the wrong variable is used as the expectation”.

However, as Chari (1999) [17] advises, by the late 1960s, there was a consensus among macroeconomists that the Phillips curve was a central feature of business cycles. A. W. Phillips (1958) [22] plotted the rate of growth of nominal wages against the unemployment rate for the United Kingdom and showed that these variables were negatively associated. Subsequent analyses focused on the relationship between the inflation rate and the deviations of gross national product from a trend. A stable relationship of this kind suggests that monetary authorities can lower unemployment at the cost of a somewhat higher inflation rate and vice versa [17].

Milton Friedman (1968) [23] and Edmund Phelps (1968) [24] were the first to argue that people care about real quantities, not nominal ones. Once people anticipate sustained inflation, they will adjust their pricing, employment, and job search decisions in ways that take inflation into account, rendering the inflation irrelevant to real economic decisions. This set the stage for Lucas and his rational expectations revolution.

Lucas expands on Muth's work and sheds light on the relationship between rational expectations and the monetary policy. He is named by the Royal Swedish Academy of Sciences “the economist whose work has had the greatest impact on the development of macroeconomics and macroeconometrics since 1970.” Lucas (1972) [25] makes a substantive and a methodological contribution. His model suggests that individuals adjust their expectations in response to changes in the money supply, which eliminates the effect on real variables such as output and employment. He argues that a stable monetary policy that is consistent with individuals' rational expectations will be more effective in promoting economic stability than attempts to manipulate the money supply.

In 1973, Thomas Sargent published the article “Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment” - another important contribution to the development and application of the concept of rational expectations in economic theory and policy. Sargent (1973) [26] argues that rational expectations can help explain fluctuations in key economic variables such as, the real interest rate and the natural rate of employment. He also suggests that there is a trade-off between unemployment and inflation in the short run, but in the long run, the economy will return to the natural rate of unemployment, which is determined by structural factors. Sargent argues that policymakers should take this concept

into account when setting macroeconomic policy, as policies that try to push unemployment below the natural rate will only lead to higher inflation in the long run.

What we can conclude is already stated by [27]: “rational expectations revolution has convinced policymakers that expectations are a key element in agents’ economic behavior, and thus, in deciding on what policies to implement, must take the expectations into account”.

In the 1970s and 1980s, Robert Lucas and Thomas Sargent further developed the rational expectations theory. Moreover, in the 1990s, Sargent went on to refine or extend its reasoning by further studying the conditions under which systems with bounded rationality of agents and adaptive learners converge to rational expectations.

“It should not be surprising that the debate about the rational expectations hypothesis has continued unabated in the nearly 50 years since Muth first published his theory. Perhaps it is as Lovell (1986) [28] lamented two decades ago in his review of empirical tests of the rational expectations hypothesis: “Why should data spoil such a good story?” ... The hypothesis has proved to be enormously productive in transforming macroeconomic theory, given that the rationality assumption enables the powerful tools of optimization to systematically expand the depth and breadth of economic theories” [29]. The rational expectations revolution has led to many different schools of macroeconomic research, i.e. the new classical economics school, the real business cycle school, the new Keynesian economics school, the new political macroeconomics school, and the new neoclassical synthesis [30].

Despite the high adoption of the rational expectations hypothesis in the economy, a number of critiques have also been raised. Salmon (1994) [31] accuses the rational expectations revolution economists for having been more concerned with how people should behave rather than with how they behave in reality. Mankiw (2006) [32] seizes the problem of unrealistic assumptions stemming from the lack of information and possible human error. Moreover, he considers the empirical support of the rational incorporation of expectations in decision-making limited. David Romer (2000) [33] opens the topic about the misspecification of models. The rational expectations theory assumes that individuals have a common understanding of the model used to make predictions. However, if the model is misspecified, this can lead to incorrect predictions. Shiller (1980) [34] criticizes the theory for inability to explain certain phenomena, such as bubbles and crashes in financial markets, etc.

However, criticism is not bad. This is a way a theory to evolve and improve.

### **2.3 Boundedly rational expectations**

In recent years, survey-based data on expectations has been growing exponentially and has been proving that empirical expectations “repeatedly deviate from implied rational expectations” [35]. Visco (2009) [36] summarizes that: “Dynamic stochastic general equilibrium (DSGE) models, which have been the workhorse of the new classical (and neo-Keynesian) macroeconomics originating from the rational expectations revolution, began increasingly to allow for the presence of rigidities and free parameters directly linked to intuitions on the actual workings of the economies that predated the rational expectation revolution”.

But what are these rigidities? The cognitive, decision-making capacity of humans faces a number of limits, such as: information failure (there may be not enough information, or it may be unreliable), limited amount of time to make decisions, limits of the human brain to process every piece of information and consider every possibility, etc.

The result is that to make decision, instead of performing exhaustive research of all possible choices, we end up using “rules of thumb” or heuristics, i.e. we apply boundedly rational models.



One of the earliest bounded rationality hypothesis belongs to Herbert Simon (1955, 1987) [37-38]. He assumes that agents instead of performing exhaustive searches over all possible decisions, they perform limited searches, accepting the first satisfactory decision. In 2003, Sims [39] defines the behavioral model of rational inattention according to which agents may rationally not account for information and use different information sets. Similarly, Gabaix (2014) [40] proposes a model in which the economic agents adopt a simplified model of the economy and pay attention only to some of the relevant variables. Angeletos and Lian (2018) [41] develop a model with dispersed and heterogenous information in which agents update their information but the news they get is imperfect, so that they partly integrate it in their forecast. Cornand and Hubert (2022) [42] puts the models of Sims (2003) [39] and Angeletos and Lian (2018) [41] under the category “noisy information models” because the actions have a random component. However, we believe all four could fall in it.

An information rigidity alternative to the noisy information models is the sticky information model. Mankiw and Reis (2002) [43] propose this model, influenced by the sticky prices of Calvo (1983) [44]. In this model the agents know the true probability distribution of the economy, that is, they have access to rational expectations, but update their information set each period with certain probability.

Another type of boundedly rational models are models in which agents may display some kind of learning behavior. “In these models, economic agents are rational and have full access to new economic information, however they don’t know the parameters that govern the economic model... Expectations are then formed by using tentative estimates. This type of model helps to explain the persistence of inflation expectations” [45]. The roots of this stream of literature can be found in the adaptive expectations models analysed earlier. Interest in them has been expressed also by rational economists. “Muth himself advanced his own rational expectations hypothesis in order to estimate the parameters of a model of adaptive expectations (where the change in the expected price level depends only on the forecast error just observed). Learning by boundedly rational agents is central also to Sargent’s successive research on expectations in macroeconomics, where the limitations of the straightforward rational expectation hypotheses are contrasted with a more nuanced view of rationality, one that weakens the strong informational assumptions implicit in Lucas’s and Sargent’s original contributions [35]”. See Evans and Honkapohja (2001) [2] for a general survey on learning in macroeconomics.

While learning models have long ago been built into macroeconomic theories, there have been other experimentally founded models such as the Adapt Rational Equilibrium Dynamics (ARED) of Brock and Hommes (1997) [46] and Anufriev and Hommes (2012) [47] – a heuristic-switching model with heterogeneous expectations. “In ARED agents choose between a costly rational expectation forecast and a cheap naive forecast, and the fractions using each of the two strategies evolve over time and are endogenously coupled to the market equilibrium price dynamics. In this setting, agents are backward looking in the sense that strategy selection is based on experience measured by relative past realized profits. When the selection pressure to switch to the more profitable strategy is high, instability and complicated chaotic price fluctuations arise” [48]. Hommes and Lustenhouwer (2019) [49] use this model to analyze inflation targeting and central bank credibility.

Last but not least, we will trace a link between behavior optimizing and Keynes theory which had advanced its time. It was the recent crashes - the financial crisis 2008-2011 and the Corona crisis in early 2020 – that triggered huge discrepancy between empirical findings and rational models and thus, led to a series of developments of a behavioral microfoundation of macroeconomics combined with the Keynesian Beauty Contest (BC).

The basic idea of the BC is that in a given setup agents need to form beliefs about the current decisions of others. The heterogeneity in behavior and beliefs of different players has led to the so-called level  $k$  model [50], and some variations. In the level  $k$ , subjects are asked

to choose a number between 0 and 100, the one being closest to two-thirds of the average of all chosen numbers receiving a fixed price. All other players receive nothing. In the case of a tie, the prize is split between those who tie. Following Nagel (1995) [50], the literature has extended the level k model. More recently, Garcia-Schmidt and Woodford (2019) [51] introduce level k into a New-Keynesian model in respect to an empirical observation that a prolonged period of low nominal interest rates during the financial crisis has not resulted in high inflation. For an extensive survey about level-k, we suggest one to refer to Crawford et al. (2013) [52].

Finally, the idea of higher-order beliefs in forecasting has also raised interest in the empirical literature in macroeconomics. Coibion et al. (2018) [53] introduce a survey to New Zealand firm managers, not only eliciting their expectations about inflation but also asking them about their beliefs of other managers and measuring their depth of reasoning in an incentivized p-Beauty Contest task.

### 3 Conclusion

Economic expectations have roots back in the Ancient times. However, the models of formation have been evolving over time, with the new knowledge available and the changing needs. At moments, this evolution has rediscovered some techniques foreshadowed earlier. At moments, it has come with completely new suggestions. There is one thing, for sure, that has always been accepted – expectations matter and this is especially valid for their macroeconomic policy implications.

Although there is little convergence on what is the best approach to model expectations, the author finds boundedly rational models adequate, realistic and efficient in tracking how beliefs feed into the economic decisions of agents. Yet, the author admits that they need to be further developed to fully identify the main drivers of disagreement observed across agents. And there is optimism that with new survey data becoming available by the day and the rebound of inflation levels around the world, academic research will catch up documenting and understanding formation and implications of expectations and particularly of those related to inflation.

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