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Rational thinking under costly information—Macroeconomic implications

Orlando Gomes*

Lisbon Higher Institute of Accountancy and Administration (ISCAL/IPL), Avenida Miguel Bombarda 20, 1069-035 Lisbon, Portugal
Business Research Unit (BRU/UNIDE/ISCTE), Portugal

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ABSTRACT

The notion of optimized rational behavior in the formation of expectations is used in this note to study the dynamics of a simple macroeconomic model. In a setting where departures from stability are not possible under perfect foresight, the selection of an optimal degree of rationality may lead to the generation of long-term endogenous fluctuations.

1. Introduction

The concept of rational behavior is one of the most debated in Economics. Because the extent of rationality determines how agents formulate expectations, the underlying assumptions one takes at this level are of primary importance. Recent literature has pointed to a relevant distinction between the benchmark notion of rational expectations and other types of rational behavior that do not necessarily imply the use of all existing information in order to forecast the future and take decisions. Even if we concede that it is possible to collect and process sufficient information in order to formulate a rational expectations/perfect foresight forecast, agents may find it optimal not to access such information integrally when relevant costs are involved.

To be rational does not necessarily mean a predisposition to gather information by any means in order to generate the best possible forecast. Rather, one is rational when, faced with the benefits and the costs of acquiring a more accurate view of the world, an optimal evaluation of available options is pursued. If we accept the neoclassical interpretation of the economic reality according to which agents optimize their behavior, rational expectations emerge as an unnatural outcome since they would imply that the acquisition of information would involve only benefits and no costs.

The work by Brock et al. (2006) and Dudek (2010) introduces a contemporaneous view on 'optimized rationality' in trivial macroeconomic environments.[1] The main consequence of this change on how the formation of expectations is dealt with concerns the possibility of finding long-term endogenous fluctuations in an environment where, otherwise, plain convergence towards a fixed-point is observed. Permanent bounded instability in a completely deterministic setting may emerge as the result of a more sensible approach to how agents collect information in order to generate expectations about future states of the world.

Endogenous cyclical motion is a common feature found in models that apply concepts of rationality that depart from the benchmark concept of rational expectations. For instance, Bullard (1994), Schonhofer (1999) and Gomes (2010) discuss how adaptive learning mechanisms are in the essence of the departures from well behaved economic time series that simply converge to or

* Correspondence to: Lisbon Higher Institute of Accountancy and Administration (ISCAL/IPL), Avenida Miguel Bombarda 20, 1069-035 Lisbon, Portugal. Tel.: +351 93 342 09 15; fax: +351 217 162 540.
E-mail addresses: omgomes@iscal.ipl.pt, ogomes@escs.ipl.pt.

[1] Going back in time, one can identify other contributions that have pioneered the research on this subject, as it is in the case of Darby (1976).

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diverge from a fixed-point steady-state. The difference between 'optimized rationality', as discussed above, and the literature on learning is that the first does not necessarily assume an evolutionary process that culminates in a steady-state of more or less successful learning; rather, at each time period, the assumed agent has the possibility of choosing the amount of information given the benefits and the costs associated with making accurate forecasts.

This note intends to emphasize the relevance and the intuitive power of the notion of 'optimized rationality' to address macroeconomic phenomena. A simple macroeconomic model is presented; for this model, an explicit evaluation of the steady-state and of stability conditions is undertaken. Results point, on one hand, to the inefficiency provoked by the fact that agents are unwilling to use all the available information and, second, to the presence of endogenous fluctuations for particular economic conditions.

The remainder of the note is organized as follows. Section 2 describes the model. Section 3 is destined to the presentation of the mechanism of formation of expectations. Section 4 proceeds with the characterization of macro-dynamics. Finally, Section 5 concludes.

2. A simple macroeconomic environment

Consider a monopolistically competitive market environment, in which every firm acts with the purpose of maximizing profits. Following Mankiw and Reis (2002), we represent the solution of this problem as

$$p_t^* = p_t + \alpha y_t. \tag{1}$$

All the variables in (1) are expressed in logarithmic form. Variable p_t^* is the desired price, i.e., the price each firm wants to set as the result of solving the respective optimization problem, p_t respects to the aggregate price level and y_t defines the output gap. Parameter $\alpha \in (0, 1)$ is a measure of real rigidities or the degree of substitutability between different varieties of the assumed good.

In this setting, all firms are identical in wanting to set price p_t^* but they are also similar in what concerns their ability to forecast this price. We assume that price decisions are taken at the end of period $t-1$, and thus the price selected by every firm (which is, then, coincidental with the aggregate price level) will be $p_t = E_{t-1}(p_t^*)$. Subtracting both sides of this last relation by p_{t-1} and defining $\pi_t := p_t - p_{t-1}$, we obtain $\pi_t = E_{t-1}(\pi_t) + \alpha E_{t-1}(y_t)$.

Now, we consider a simple money market equilibrium relation,

$$m_t = y_t + p_t \tag{2}$$

where m_t is money supply (this is also presented under logarithmic form). Monetary policy will be given by a trivial rule of constant growth: $m_{t+1} - m_t = \Delta m \geq 0$. Combining Eq. (2) with the inflation rate expression and applying first-differences, we obtain an equation that describes an extremely simple macroeconomic scenario; this equation is

$$\pi_{t+1} = (1-\alpha)\left[E_t(\pi_{t+1}) + \pi_t - E_{t-1}(\pi_t)\right] + \alpha\Delta m. \tag{3}$$

The behavior of the inflation rate over time will depend on the assumption underlying the formation of expectations. Under perfect foresight, the inflation rate will just be identical to the rate of money growth: $\pi_{t+1} = \Delta m$ and Eq. (3) will involve no dynamic relation whatsoever. This result changes when we sophisticate the way we look at the formation of expectations, as we do in the next section.

3. Formation of expectations—The optimal predictor

At time t, firms will take p_{t+1}^* as a random variable. Agents have the possibility of collecting information in order to improve the quality of their expectations, but this process of information acquisition is costly. Hence, a choice has to be made; there will be a continuum of available forecasting rules from which the firm selects one; the better the quality of the chosen predictor, the more this will cost. At t, a firm can purchase a signal with the following characteristics:

$$\upsilon_t = \begin{cases} p_{t+1}^* \text{ with probability } q \text{ (predictor reveals true value)} \\ p_t^* \text{ with probability } 1-q \\ \quad \text{(predictor is totally uninformative).} \end{cases}$$

Thus, when buying a predictor of quality $q \in (0, 1)$, the firm acquires a signal υ_t as described above. The acquisition of an information signal has costs. Assume the following increasing and convex cost function: $C(q) = \frac{1}{2}\psi q^2,\ \psi \geq 0$.

The expectation of an agent choosing the perfect foresight forecast with probability q and the naive forecast with probability $1-q$ is:

$$E_t[p_{t+1}^* | \upsilon_t] = q p_{t+1}^* + (1-q) p_t^*. \tag{4}$$

In order to optimally choose the quality of the signal, each agent computes the difference between expected and observed target prices and minimizes the sum of this difference with the costs of collecting information. The trade-off between fitness of expectations and information acquisition sets the optimal predictor quality. The problem at hand becomes:

$$\underset{q}{\text{Min}}\ U_t, \quad \text{with } U_t = \frac{1}{2}\left[E_{t-1}(p_t^*) - p_t^*\right]^2 + C(q).$$

The solution of this problem is found by applying condition $\frac{\partial U_t}{\partial q} = 0$. The corresponding result is

$$q = \frac{[\alpha\Delta m + (1-\alpha)\pi_t]^2}{\psi + [\alpha\Delta m + (1-\alpha)\pi_t]^2}. \tag{5}$$

Observe that if information is costless ($\psi = 0$), then $q = 1$, i.e., perfect foresight necessarily holds. As the cost parameter departs from zero, the quality of the signal will fall. The other limit case will be $\psi \to \infty$: very large costs of information acquisition will imply that q tends to zero and expectations will be fully myopic.

Let us now return to the expectations expression (4); we reconsider it in aggregate terms[2]:

$$E_t(p_{t+1}^*) = q p_{t+1}^* + (1-q) p_t^*. \tag{6}$$

Replacing q as given by (5) into (6), we arrive to the expression of the expected value of the inflation rate:

$$E_t(\pi_{t+1}) = q_{t-1}\pi_{t+1} - \frac{\alpha}{1-\alpha}(1-q_{t-1})\Delta m. \tag{7}$$

In (7), we consider that the decision on the quality of the signal to be purchased at date t depends on the ex-post expected quality of the signal acquired at time $t-1$. This means that q_{t-1} will depend on π_t and will be used to forecast π_{t+1}.[3]

Now that we have the expected value of the inflation rate under optimal information acquisition, we can replace this value into Eq. (3). We obtain difference equation

2 In expression (6), relatively to (4), we drop signal υ_t. The two expressions differ in one important respect: the first corresponds to the individual probability of selecting one or the other type of forecast; the second is an aggregate expectations rule, according to which a fraction q of the firms in the market possess perfect foresight and a second share, $1-q$, resorts to the naive predictor. Evidently, it is the law of large numbers that allows to write the aggregate expectations as displayed in (6).

3 This is an assumption that is technically convenient, because it allows to overcome a circularity problem: the agents want to acquire a predictor that depends on future inflation, but this is not yet known in the current period. Concepts of managerial perfect foresight equilibrium and the possibility of computing an average of all the available signals are alternative ways of circumventing this problem, which are used in the related literature mentioned in the Introduction.