



# Aggregate sentiment dynamics: A canonical modelling approach and its pleasant nonlinearities



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## ABSTRACT

The paper is an attempt at an alternative to the rational expectations assumption in macroeconomic modelling. Emphasizing the concept of sentiment in contrast to the expectations of a single selected variable, it is meant to take an important step forward towards a canonical heterodox framework for the microfounded modelling of irreducible uncertainty and, specifically, herding. Referring to a large population of agents who repeatedly face a binary decision problem, two stylized approaches are considered to describe the aggregate sentiment dynamics: the transition probability and the discrete choice approach. After a slight modification of the latter, the two specifications are shown to give rise to essentially the same adjustment equations. In addition to these conceptual issues, a two-dimensional prototype model is put forward which can illustrate the rich potential of an inherent nonlinearity to generate scenarios with single and multiple (point and set) attractors.

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## 1. Introduction

It is an unchallenged axiom in almost all of current macroeconomic theory that the decisions of the agents are based on their expectations about the future course of some observable key variables, or rather their value in the next period. If there is any debate at all, it is about whether these expectations are formed in a rational or, as it is called, boundedly rational fashion, or what kind of learning processes might enable the agents to converge to rational expectations.

It may nevertheless be recalled that this point of view has been seriously called into question by, in the first instance, Keynes in Chapter 12 of his *General Theory*.

He there discusses another elementary “characteristic of human nature,” namely, “that a large proportion of our positive activities depend on spontaneous optimism rather than on a mathematical expectation” (Keynes, 1936, p. 161). Although the chapter is titled “The state of long-term expectation”, Keynes makes it explicit that he is concerned with “the state of psychological expectation” (p. 147).<sup>1</sup> However, this state does not arise from whims and moods out of the blue, it is not an imperfection or plain ignorance of human decision makers. In the end it is due to the

<sup>1</sup> The famous “animal spirits” are mentioned in the same chapter on p. 161. While in modern DSGE models this term is used interchangeably with sunspot equilibria and self-fulfilling prophecies, it will be clear enough that the discussion in the present paper has nothing to do with these refinements of rational expectations where the observations of an exogenous stochastic process induce the agents to coordinate on recurrent switches between multiple equilibria.

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problem that decisions reaching further into the future are not only complex but also fraught with irreducible uncertainty. “About these matters”, Keynes writes at another place to clarify the basic issues of the *General Theory*, “there is no scientific basis on which to form any calculable probability whatever” (Keynes, 1937, p. 114). To cope with this fundamental fact when inevitably a decision *has* to be taken, and “to behave in a manner which saves our faces as rational economic men” (*ibid.*), Keynes makes reference to “a variety of techniques”, or “principles”. From the three central points that he notes we may here quote the last one, which in today’s language is furthermore reminiscent of herding behaviour:

“Knowing that our own individual judgment is worthless, we endeavor to fall back on the judgment of the rest of the world which is perhaps better informed. That is, we endeavor to conform with the behavior of the majority or the average. The psychology of a society of individuals each of whom is endeavoring to copy the others leads to what we may strictly term a *conventional judgment*.” (Keynes, 1937, p. 114; his emphasis).<sup>2</sup>

These brief sketches may suffice to illustrate that it should be fruitful in macroeconomic theory to give the same or even higher priority to an axiom that provides an alternative to the exclusive focus on the expectations of specific macroeconomic variables. It may read, *the long-term decisions of the agents are based on sentiment*. This kind of decision-making comprises more dimensions and is usually more diffuse than a mere reference to expectations.

Even though one may be sympathetic to this idea in its generality, it is quite another matter how some crucial aspects of sentiment should be translated into the language of rigorous formal modelling. Unfortunately, the macroeconomic literature is rather limited and scattered in this respect.<sup>3</sup> What is required is a stylized ‘canonical’ framework (Lux, 2009, p. 640) on which economists interested in the concept of sentiment can agree. From originally the literature on agent-based asset pricing models two candidates are available for this, both of which describe the dynamic adjustments of a macroscopic sentiment index and refer to a large population where, in the simplest case, the individual agents repeatedly face a binary decision problem. If therefore, for example, the agents choose between an optimistic and pessimistic view concerning the prospects of their fixed investment, the difference between the population shares of optimists and pessimists could be interpreted as a general business sentiment determining aggregate investment demand (as in Franke, 2012). On

this basis, the two approaches allow the agents to switch from one alternative to the other with time-varying probabilities, where one approach introduces the concept of transition probabilities and the other makes use of the logit probabilities from discrete choice theory.

In both cases, the probabilities are functions of other variables in the model. The transition probability approach typically includes a majority index in a way that makes it possible to capture herding, while applications of the discrete choice approach mostly refer to some kind of the current ‘fitness’ of the two options. However, both approaches can easily make their probabilities dependent on the same set of variables. Although even then the adjustment equations for the population shares at the macro level do not look the same, it may be felt that they have similar implications.

It is the purpose of the present note to point out that for interpretational reasons the discrete choice approach may in the present context be better replaced by a ‘smoothed’ version of it, which is formally known as logit dynamics. We then go on to show that this conception essentially amounts to the same as the transition probability approach. The result is based on quite elementary arguments and may be a step further towards the aforementioned canonical framework for the modelling of a microfounded sentiment dynamics.<sup>4</sup> In addition, the specifications here involved exhibit a fruitful nonlinearity that can give rise to a variety of dynamic scenarios with single and multiple, point and set, attractors. This potential will be illustrated with a two-dimensional prototype model at the end of this note. Upon the *ceteris paribus* variations of a parameter that, taking up Keynes’ quotation from above, represents the intensity of herding, it yields a nice succession of five different local and global bifurcations.

## 2. Common background

The individual agents in the economy face a binary decision problem. For the ease of reference, let us suppose that they can entertain two alternative attitudes: an optimistic and a pessimistic view. Let  $n^+$  be the share of optimists and  $n^-$  the share of pessimists ( $n^+ + n^- = 1$ ). In reducing the number of dynamic state variables, their law of motion will be specified in terms of the difference  $x := n^+ - n^-$  between the two groups. Following the discussion in the Introduction, this variable will here be referred to as the general *sentiment* prevailing in the economy. Synonymous expressions are business (or consumer) sentiment, business climate, the general state of confidence, or more loosely but conspicuously: the celebrated animal spirits. By construction,  $x$  is contained between  $-1$  and  $+1$ .<sup>5</sup>

<sup>2</sup> A more extensive discussion of Keynes’ concepts that can be related to the present paper may be found in Flaschel et al. (1997, Chapter 12.2), or more generally in Minsky (1975, Chapter 3). A good survey of the role of (psychological) expectations and confidence is given in Boyd and Blatt (1988). The recent book by Akerlof and Shiller (2009) on *Animal Spirits* certainly needs no further referencing.

<sup>3</sup> It even seems to us that a subcommunity of heterodox theory loves to talk about the significance of “animal spirits” and similar concepts but, when it comes to rigorous macrodynamic modelling, is not very interested to put up a forceful alternative to rational expectations. In particular, the influential and otherwise meritorious Kaleckian approach is largely silent in this respect.

<sup>4</sup> As these “microfoundations” emphasize endogenous heterogeneity, it goes without saying that they are fundamentally different from the intertemporally optimizing representative agent for whom this expression is usually reserved (although, as we cannot resist adding a quote from Solow (2004, p. 660), “one could even question whether a representative-agent model qualifies as microfoundation at all”).

<sup>5</sup> Instead of optimists and pessimists, one could also think of the choice between two decision rules or, not sharing the present emphasis on the concept of ‘sentiment’, two forecasting devices.

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