

Kirman, Alan. "Ants, Rationality, and Recruitment". Quarterly Journal of Economics, Vol. 108, Issue 1, 1993, 137-156.

### **Chaotic Economics**

"Ants, Rationality, and Recruitment" forms the basis of what I consider to be one of the most exciting, important, and enlightening developments in economics to date: the shattering of deterministic economic models and their replacement with methods deeply rooted in the chaotic nature of human behavior. Paul Omerod's 1998 work Butterfly Economics<sup>1</sup> makes great leaps in this direction; he cites Alan Kirman's groundbreaking work in the development of chaotic models of interacting economic agents. Inspired by Omerod's fascinating book, I decided to examine Kirman's work in order to understand more fully the fundamentals of this new economic paradigm. I found his article through EconLit by searching for it directly. EconLit also returned eighty-five hits for the author Alan Kirman, and listed 185 matches for "biology" and 518 returns for "chaos".

In his paper<sup>2</sup>, Kirman puts forward a mathematical model that explains the recruiting, herding, and epidemic behaviors exhibited by both ants and financial traders. He captures and reproduces this behavior through a mathematical model based on internal dynamism and positive feedback, two central tenets of chaos theory. Kirman's research opens the floodgates for further discovery into the chaotic nature of human economic behavior.

Kirman opens with a discussion of the peculiar findings of two groups of entomologists that resulted from studies of ant behavior. Placing two identical, constantly replenishing sources of food equidistant from an ant colony, these scientists hypothesized that the feeding level at each source would behave like the swinging of a pendulum, shifting rapidly at first and over time settling on an equilibrium point where the ants would consume equal amounts of food from each source. This did not take place. Instead, the entomologists observed that the ants would focus almost all of their feeding activity at one site, appearing to stabilize in the short run around an 80% - 20% split. In the long run, however, the ants displayed a second counter-intuitive behavior. Without any warning or outside provocation, the ants were observed to switch their focus from the source they had been utilizing to the other. They still maintained a balance around 80% - 20%; the only thing that had changed was which source was receiving the ants' attention. The entomologists' model, which utilized differential equations, was able to reflect the unexpected split, but was unable to fully take into account the sudden "flips".

A critical component of ant foraging behavior is that they exhibit the ability to "recruit". That is to say, when one ant finds food, it both physically stimulates other ants and lays chemical secretions in a trail for other ants to discover. This creates a system of *positive feedback*, meaning that the act of one ant finding food directly causes large numbers of additional ants to utilize that same source of food. An ant can still hunt for its own food, but the chance of this occurring is relatively small in comparison. In this way, the colony appears to act as if it is

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<sup>1</sup> Omerod, Paul. Butterfly Economics. Faber and Faber Ltd., London, 1998.

<sup>2</sup> In this report, I seek to convey the essence of Kirman's discoveries in a form easily digestible to the reader. As such, the body of this paper consists of re-presenting Kirman's own ideas. It seems clear that referencing each individual idea by page number would prove to be tedious and useless for the reader. Therefore, the reader is advised to consider all of the ideas presented in the article's summary as belonging to Kirman.

seeking to maximize its utility; the vast majority of the ants exploit a known food source while leaving a few to search for additional sources at all times.

Kirman captures the bizarre phenomena observed by the entomologists with a simple but mathematically sophisticated model. This model reflects the features of a large number of agents, a high propensity to switch one's behavior as a result of interacting with another agent, and a relatively low probability for one to change one's behavior on one's own. Several important features of his work deserve special attention. Primarily, Kirman's model, like the ants' behavior, is *internally dynamic*, meaning that purely endogenous factors can cause shifts in the state of the model. This occurs through the minute number of agents within the model who make decisions on their own, as these agents then begin to recruit their own followers and begin the dramatic switch to the opposite distribution. It is this notion of small causes effecting in disproportionately large changes that captures the essence of chaos theory and modeling. Secondly, one cannot predict when these switches will take place. In this way, no two runs of the model will ever be precisely the same, as the large-scale effects in the distribution are the result of minute, random actions. Finally, one cannot say that the distribution in Kirman's model ever reaches an equilibrium state; the percentages merely fluctuate violently between two extremes. For the entomologists, this was perceived as a flaw in the experiment; for Kirman, this feature is a critical component in the process of modeling chaotic behavior.

After demonstrating the effectiveness of his model, Kirman turns his attention to the economic application of his work. Essentially, traders in a market can be said to behave in highly similar ways to the ants. They can either follow a trading strategy they have previously used, switch to a different strategy on their own upon receiving new, exogenous information, or switch as a direct result from observing other agents in the same market, if they perceive that to be the most utility maximizing strategy. These patterns of behavior can easily create the "epidemics" and "herds" discussed in financial literature. The difference between Kirman's model and traditional economic models, however, cannot be overstated: in orthodox economics, changing one's behavior due to direct social interaction is seen as irrational and therefore beyond the scope of economic modeling, whereas for Kirman this is seen as an integral component of economic behavior. According to Paul Omerod, author of Butterfly Economics, this development necessitates a rethinking of business cycles, crime-management, and fiscal policy. Omerod's additional contributions essentially constitute a re-creation of economic theory, on both the microeconomic and macroeconomic levels. That his truly innovative work follows directly from "Ants, Rationality, and Recruitment" is a direct testimony to the notability of the latter.

Kirman's analysis appears to be sharp and accurate. He delves deeply into the work and debates of contemporary biologists when discussing various recruitment strategies among ants and other creatures, undergoing the task of exposing what may appear to be flaws in his reasoning, and debunking this criticism. When discussing, for example, the challenges faced by the entomologists in constructing an experiment that would clear away as many outside variables as possible, Kirman does not fail to include information on the ways in which these experimental changes necessitate altering his model. He constructs his model in digestible pieces, weaving its elaborate structure from elements comprehensible even to the mathematically unsophisticated. Though a mathematically inexperienced reader might not be able to fully comprehend all of his calculations, one can certainly grasp the concepts with which he is working and identify them and their effects in his model. His information regarding the academic ramifications of his work also demonstrates his commitment to solid scholarship. He discusses the cases of financial traders, speculative bubbles, restaurant frequenters, emerging industries, and more in the light of

his groundbreaking discoveries, illuminating these situations for the reader in a lucid, straightforward manner. Indeed, Kirman's presentation of his discoveries deserves as much praise as do his discoveries themselves.

The developments presented in Alan Kirman's "Ants, Rationality, and Recruitment" stand among the most groundbreaking discoveries made in the field of economics in decades. Indeed, his work challenges the most fundamental assumptions of economic models and philosophy of mechanistic determinism and the absence of social influences on economic actors. In time, Kirman's findings will most likely take their place among the great theoretical leaps in economics, ushering in an era of economics based firmly on the principles of chaos.