De Economist
150 (5) 2002

Masanao Aoki, *Modeling Aggregate Behavior and Fluctuations in Economics: Stochastic Views of Interacting Agents*, Cambridge University Press, Cambridge, 2002. 263 p. GBP 47.50 (ISBN 0 521 78126 4 HB), GBP 17.50 (ISBN 0 521 01068 3 PB)

For people interested in applying a mature mathematical probability model to a diverse range of economic phenomena, Masanao Aoki's book shows that a single structure with only minor *ad hoc* phenomenon-specific alterations can astoundingly explain a broad range of econonomic behaviour. From an industrial organisation perspective, Aoki models firm behaviour in terms of market share competition by imitation or innovation. From a macroeconomic viewpoint, growth and business cycles are phenomena covered by the model. The Diamond search model from labour economics is reformulated in terms of Aoki's approach. Finally, the market micro structure of financial markets is modelled to describe price dynamics and the phenomenon of volatility clustering. All these phenomena are described within one mathematical structure. While the focus of the book is on describing economic phenomena Aoki links his model to the literature on amongst other things statistics, physics, population genetics, ecology, and operations research. The broad coverage of the model already suggests that Aoki is working on a high level of abstraction. In general terms he models a large number of identities which are governed by a stochastic system. More specifically, he models the partitioning of a large number of agents as a continuous jump Markov process. The focus is on the probability distribution of various groups of agents identified by types, categories, or configurations and how these evolve over time. The partition of n agents in k categories from a probabilistic viewpoint boils down to assigning n balls to k baskets. One may think of agents as firms and types as classes of firm sizes. A second example considers agents as traders and types as trading strategies, for instance some specified assets preference structure. The business cycle phenomenon is explained by modelling agents as consumers and types as different goods and specifying the gap between supply and demand for each type of goods. Instead of modelling this gap as a deterministic adjustment mechanism, Aoki uses for this purpose a birth-death process familiar from queuing theory. Holding times are specified to describe the amount of time a firm needs to increase its production size. The transition probabilities governing the systems motion from one state to another are modelled state dependently which makes them endogenously determined by optimising agents. The motion of the stochastic system is described by the well-known backward Chapman-Kolmogorov equation. The locally stable equilibria for aggregate variables are derived and the fluctuations around these equilibria are identified by the so-called Fokker-Planck equation. Without going into technical detail for all applications it holds that as the number of agents approaches infinity the deterministic macroeconomic relations of more conventional economic models are recovered.

The second part of the book contains random combinatorial analysis and investigates how agents form clusters of various sizes. Consider for example traders in a financial market employing various strategies or trading rules. All agents with the same trading strategy form a cluster. These clusters evolve over time as agents enter or exit the market and also as they switch their strategy in response to changing market sentiments. Aoki derives conditions under which clusters of traders willing to buy and traders willing to sell balance.

Share prices as a result of excess demand or excess supply can be described as a function of the clustering behaviour of agents.

While applying Markov chain and combinatorial techniques which are popular in the hard sciences, but alien to traditionally trained economists, Aoki tried to keep the mathematics tractable. The elegance of his approach lies not so much in the economics, but in the modelling and interpreting of a variety of phenomena within a single structure. The core of the model is to describe macroeconomic behaviour based on individual microeconomic contribution decisions. The model can deduce (nearly) deterministic aggregate behaviour and associated fluctuations starting from probabilistic descriptions of individual agents. As such the model is able to track the underlying propagation mechanisms turning individual stochastic behaviour into observed aggregate patterns.

The underlying stochastic nature of the model is that a large number of agents optimise their respective objective functions in an environment of idiosyncratic shocks. This assumption makes Aoki's approach very much different from the mainstraim microeconomic and game-theoretic practice of identifying representative agents and formalising their individual mutual interdependencies. In the latter approach most often each agents pay-off function incorporates the possible actions of all other agents, which is more suited for describing individual rational behaviour and understanding evolving economic patterns on a mesoeconomic scope explaining a single unique economic phenomenon. Contrarily, Aoki's Markov model assumes a large number of mutually independent heterogeneous agents only reacting to an environment consisting of aggregate behaviour. Therefore the model lacks the connection to mainstraim microeconomic theory. However, by alternatively adopting a stochastic nature of microeconomics the model amazingly describes a variety of aggregate behaviour and economic phenomena within a single structure.

Ard den Reijer