Chapter V

Optimization of Individual and Regulatory Market Strategies with Genetic Algorithms

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ABSTRACT
An optimal policy problem is formulated for evolutionary market settings and analyzed in two applications at the micro- and macrolevels. First, individual portfolio policy is studied in case of a fully computerized, multiagent market system. We clarify the conditions under which static approaches—such as constraint optimization with stochastic rates or stochastic programming—apply in coevolutionary markets with strictly maximal players under scaled genetic algorithms. Convergence to global optimum is discussed for (a) coevolution of buying and selling strategies and for (b) coevolution of portfolio strategies and asset distributions over market players. Because only a finite population size in our setting suffices for the asymptotic convergence, the design criteria for genetic algorithm given (explicit cooling scheme for mutation and crossover, exponentiation schedule for fitness-selection) are of practical importance.
Second, system optimization policy is studied for a model economy of Kareken and Wallace (1982) type. The income redistribution, monetary and market regulation policies are subjected to a supergenetic algorithm with various objective functions. In particular, the fitness function of a policy (i.e., a supercreature) is computed by means of a conventional genetic algorithm which is applied to the market players (creatures) in a fixed evaluation period. Here, the underlying genetic algorithm drives the infinite market dynamics and the supergenetic algorithm solves the optimal policy problem. Coevolution of consumption and foreign currency saving policies is discussed. Finally, a Java model of a stationary market was developed and made available for use and download.

INTRODUCTION

Evolutionary market models are a useful tool to investigate properties of real markets. This work deals with applications of the genetic algorithm (GA) in simulated agent-based artificial markets at micro- and macrolevels from methodological viewpoint. GA applications to agent’s portfolio optimization problem (micro) and market/society optimization problem (macro) are discussed in the context of coevolution.

The microlevel problem of choosing optimal portfolio has been intensively studied since the pioneering works on portfolio optimization Markowitz (1952) and Tobin (1958) by financial investment companies and in academia (cf. Markowitz, 1991; Michaud, 1998). The first research direction is based on phenomenological studies, statistics and data mining applied to aggregate data from asset markets and their derivatives. The second line of investigation is based on computerized bottom-up techniques, starting with behavioral models at the microlevel, implementing market information models, and the price-making mechanism. This yields complete data time series both at the micro- and macrolevels. Although macroscale simulation results are a subject to comparison with real markets, microscale simulation output data offer insight into the market dynamics and its underlying mechanisms.

This work first deals with the portfolio optimization problem in closed simulated markets, in which total finance \( m \) and nominal amounts of all kinds of stock, \( q_i \), are constant; price matching is a deterministic algorithm adjusted to imperfect information condition by using time series of closed auctions. In particular, we adopt the common market model by Yuuki, Moriya, Yoshida and Pichl (see Figure 1). In the YMYP model, the self-contained market is further coupled to the external world through stochastic time series of dividend yields per each stock simulating data from actual markets. In this framework, the time series of stock prices and traded volumes result from the actions taken by each agent: keep, buy, or sell. In addition, we consider an alternative non-correlated investment asset \( d \) with a fixed yield rate \( r \). Hence the portfolio is a tuple of \( \{m, d, q_i\} \) which is recursively evaluated in discrete steps (market sessions). The portfolio is to be optimized with respect to a certain utility function. If the market initial state is set and the agents behavioral rules are fixed, each agent/portfolio holder optimizes the function of \( n-1 \) variables, which is computed by fully deterministic algorithm \( A \) consisting of a set of agent behavioral rules and the price making mechanism.

Either \( A \) is ex ante known to each dealer (shared theory) or \( A \) is generally unknown (individual behavioral rules). In the latter case, \( A \) can be studied ex post by data mining.
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