Information Fusion 14 (2013) 327–333

Contents lists available at SciVerse ScienceDirect

Information Fusion

journal homepage: www.elsevier.com/locate/inffus

Exchange rates determination based on genetic algorithms using Mendel's principles: Investigation and estimation under uncertainty

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ARTICLE INFO

Article history:
Received 29 May 2011
Received in revised form 18 October 2011
Accepted 26 December 2011
Available online 8 January 2012

Keywords:
Genetic algorithm
Mendel's principle
Uncertainty
Estimation
High-frequency
Exchange rates
Regression

ABSTRACT

A genetic algorithm using Mendel's principle (Mendel-GA), in which the random assignment of alleles from parents to offsprings is implied by the Mendel genetic operator, is proposed for the exchange rates determination problem. Besides the traditional genetic operators of selection, crossover, and mutation, Mendel's principles are included, in the form of an operator in the genetic algorithm's evolution process. In the quantitative analysis of exchange rates determination, the Mendel-GA examines the exchange rate fluctuations at the short-run horizon. Specifically, the aim is to revisit the determination of high-frequency exchange rates and examine the differences between the method of genetic algorithms and that of the traditional estimation methods. A simulation with a given initial conditions has been devised in *MATLAB*, and it is shown that the Mendel-GA can work valuably as a tool for the exchange rates estimation modelling with high-frequency data.

1. Introduction

The modelling of exchange rates movements is a challenging task in international finance. A strong consensus in academic research is that macroeconomic fundamentals have no explanatory power for exchange rates fluctuations in the short run [1,2]. In contrast, microstructure approaches focus on how is information concerning the macrofundamentals, non-fundamentals and its transfers in the foreign exchange market, and impacting the movement of exchange rates. Empirical evidence demonstrates the significant positive link between exchange rates and their corresponding contemporaneous order flow, which is defined as the net value between buyer-initiated trade and seller-initiated trade [3–5].

Other evolutionary computation (EC) methods were proposed for exchange rates analysis, and other financial studies. In 1996, Hann and Steurer [6] analysed the influences of data frequency on American Dollars/Deutsch Mark forecasting by artificial neural networks (ANNs), in which the studies reported that the ANN do not greatly improve the forecasting accuracy when monthly data is applied. In 2003, Qi and Wu [7] proposed a multi-layer feed forward network to forecast exchange rates, the numerical results of which concluded that the ANN cannot perform efficiently in out-of-sample forecast accuracy. In 2007, Yadav et al. [8] applied standard multi-layer neural network (SMN) to predict a set of time-series data for an exchange rate prediction from 2002 to 2004.

In 2005, Rimcharoen et al. [9] proposed a method of adaptive evolution strategies (ESs) for the prediction of the stock exchange of Thailand, in which the GA method was combined with the ES method. No further reports about ES for prediction of exchange rates studies have been made.

A differential evolution (DE) algorithm, combining the strengths of multiple strategies, was proposed by Worasucheep and Chongstitvatana [10] in 2009, but there is no further studies on the exchange rates determination by the DE or DE related methods.

The particle swarm optimisation (PSO) method is one of the swarm intelligence algorithms, which is a population-based search algorithm following the social behaviour of individuals (particles) moving among a multi-dimensional searching space. The PSO method was applied to stock markets forecasting, by working with ANN, by Nenortaite and Simutis [11] in 2004, and by Zhao and Yang [12] in 2009, but neither reports on the PSO applications for exchange rates prediction.

Genetic Algorithms (GAs) were introduced in the 1970s by Holland [13] at the University of Michigan. Inspired by Darwin's theory of evolution, they apply three basic genetic operators – selection, crossover, and mutation – to a population of individuals. The practical problems are often characterised by several

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doi:10.1016/j.inffus.2011.12.003

non-commensurable and competing measures of performance or objectives, with a number of restrictions imposed on the decision variables. The choice of a suitable compromise solution from all non-inferior alternatives is not only problem-dependent, it generally depends also on the subjective preferences of a decision agent. Thus, the final solution to the problem is the result of both an optimisation process and a decision process.

In recent years, a lot of literature has been proposed in the area of GA using Mendel's principles [14–19]. In this paper, a new GA method using Mendel's principles (Mendel-GA) is proposed, which includes the following differences to the standard GA method and previous research:

(1) In this paper, the Mendel operator is inserted after the selection operator, which can thus take advantage of the Mendel operator's local search ability, as shown in Fig. 1. In previous researches [16–19], the Mendel operator was inserted into the GA process after the mutation operator. Based on mutation probability P_m, mutation may generate an unstable population, which will lead to polluted outputs for the whole evolutionary processes biologically and mathematically[20,21]. Typically, the mutation operator is a randomly introduced changing of a binary bit from a '0' to a '1', and vice versa. The basic method of mutation is able to generate new recombination of improved solutions at a given rate, but the possibility of damage to the dominated population, loss of good solutions and convergence trend also occurs[22–24]. The Mendel operator will amplify such an unstable population with its local search ability from a microevolutionary point of view.
(2) Mendel's principles are represented by the Mendel operator, which is easily synchronised with the multi-objective GA processes, such as multiple objective genetic algorithm (MOGA) [25], niched pareto genetic algorithm (NPGA) [26], non-dominated sorting genetic algorithm (NSGA) [27] and non-dominated sorting genetic algorithm II (NSGAII) [28].
(3) The standard GA is based on Darwin's theory, which is represented by the differential survival, and reproductive success; in the Mendel-GA, Mendel's law is indicated by the equal gametes, which unite at random to form equal zygotes and reproduce equal plants throughout all stages of the life cycle.

Exchange rates determination has been regarded as one of the most challenging applications of high frequency time series trading [3–5,29,30], and, to provide the investors and researchers with more precise predictions, some different models have been depicted in which the prices follow a random walk phenomenon. This is suitable for GA with stochastic and non-linear searching ability.

The Mendel-GA will be applied to the studies of empirical analysis on exchange rates determination, which can provide an evolutionary and computational method to the exchange rates determination problem. Specifically, it attempts to compare the performance of the Mendel-GA and the traditional estimation methods, for instance, the ordinary least square (OLS) or the linear least squares (LS) estimation. The OLS and LS are methods for estimating the unknown parameters in a linear regression model. These methods minimise the sum of squared distances between the observed responses in the data-set, and the responses predicted by the linear approximation. Compared with the OLS or LS, the Mendel-GA, by the evolutionary process, can handle linear and non-linear models with higher complexity, and it is flexible to be an active optimisation solver for switching from one prediction model to the others.

2. Exchange rates determination model

In 2001, Killeen et al. [4] found the co-integration relationship between exchange rates and cumulative order flow (COF), which is the proximate determinant of price in all microstructure models, and in 2003 Payne [5] used non-standard vector autocorrelation to examine the causality of exchange rates from the order flow.

The order flow is defined as the net of buyer and seller initiated currency transactions, which is taken as a measure of net buying pressure [3]. According to previous reports [1,4,5,31,32], the order flow is intimately related to a broad set of current and expected macroeconomic fundamentals, and as such the order flow is regarded as a useful predictor of the movements in exchange rates.

Microstructure approaches use order flow to proxy the information reflecting the movement of exchange rates. An intensive study by Obstfeld and Rogoff [1] in 2000 demonstrates that order flow contains information concerning the movements of exchange rates.

By starting from the conventional exchange rates theories, the exchange rates can be expressed as the discounted present value

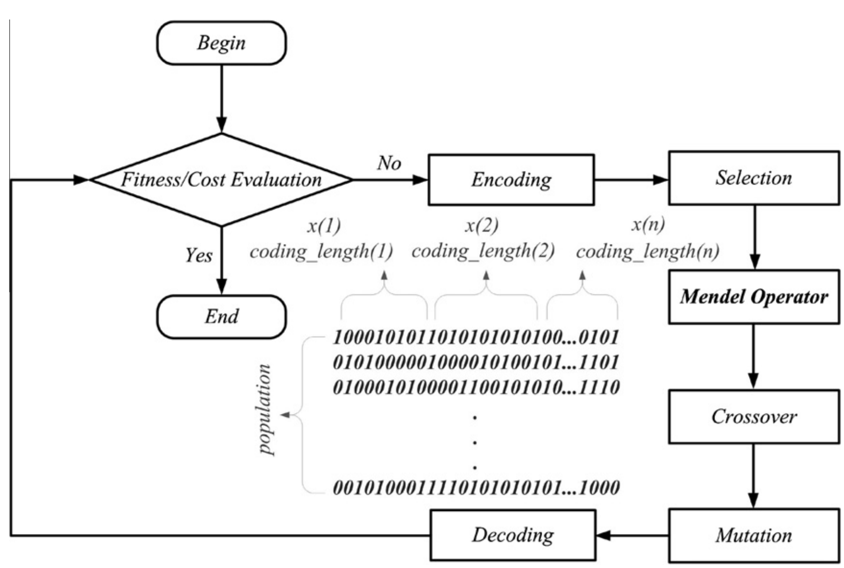

Fig. 1. Genetic algorithm using Mendel's principles workflow.