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Markovian approximation in foreign exchange markets

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Abstract

In this paper, using the exit-time statistic, we study the structure of the price variations for the high-frequency data set of the bid–ask Deutschemark/US dollar exchange rate quotes registered by the inter-bank Reuters network over the period October 1, 1992 to September 30, 1993. Having rejected random-walk models for the returns, we propose a Markovian model which reproduce the available information of the financial series. Besides the usual correlation analysis we have verified the validity of this model by means of other tools all inspired by information theory. These techniques are not only severe tests of the approximation but also evidence of some aspects of the data series which have a clear financial relevance. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Any financial theory begins introducing a reasonable model for price variation in terms of a suitable stochastic process. In this paper we want to select an asset-pricing model able to describe some features interesting from a financial point of view at *weak* level, i.e., including only information arising from analysis of historical prices and not including other public [1–4] or private [5] information.

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To attain such an aim we analyze the foreign exchange market because it presents several advantages compared with other financial markets. First of all it is a very liquid market. This feature is important because every financial market provides a single sample path, the set of the registered asset quotes. To be sure that a statistical description makes sense, a reasonable requirement is that this (unique) sequence of quotes is not dominated by single events or single trader's operations. A natural candidate for such (if possible) description is then a liquid market involving several billions of dollars, daily traded by thousand of actors. In addition, the foreign exchange market has no business time limitations. Many market makers have branches worldwide so trading can occur *almost* continuously. So in the analysis one can avoid to consider problems involved in the opening and closure of a particular market, at least as a first approximation. Finally, if one considers the currency exchange, the returns

$$r_t = \ln \frac{S_{t+1}}{S_t} \tag{1}$$

are almost symmetrically distributed, where S_t is the price at the time t defined as the average between bid and ask prices.

In this paper we investigate the possibility to describe the Deutschemark/US dollar exchange (the most liquid market) in term of a Markov process. We consider a high-frequency data set to have statistical relevance of the results. Our data, made available by Olsen and Associated, contains all worldwide 1,472,241 bid–ask Deutschemark/US dollar exchange rate quotes registered by the inter-bank Reuters network over the period October 1, 1992 to September 30, 1993.

One of the main problems when analyzing financial series is that the quotes are irregularly spaced. In Section 2, we briefly describe some different ways to introduce time in finance, and we discuss why we choose the *business* time, i.e., the time of a transaction is its position in the sequence of the registered quotes.

The history of the efforts in the proposal of proper stochastic processes for price variations is very long. An efficient foreign currency market, i.e., where prices reflect the whole information, suggests that returns are independently distributed. Following Fama [6] we shall call hereafter "random walk" a financial model where returns are independent variables. Without entering into a detailed review we recall the seminal work of Bachelier [7] who assumed (and tested) that price variations follow an independent Gaussian process. Now it is commonly believed that returns do not behave according to a Gaussian. Mandelbrot [8] has proposed that returns are Levy-stable distributed, still remaining independent random variables. A recent proposal is the truncated Levy distribution model introduced by Mantegna and Stanley [9] which well fits financial data, even considering them at different time lags.

Since the financial importance of correlations in order to detect arbitrage opportunities (see Ref. [10] for a review and Ref. [11] for more recent results) it is essential to introduce a non-questionable technique able to answer to the question: can "random walk" models correctly describe return variations?

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