Chapter II

Pricing Basket Options with Optimum Wavelet Correlation Measures

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ABSTRACT

This chapter describes a new procedure for designing optimum correlation measures for financial time series. The technique attempts to overcome some of the limitations in existing methods by looking at correlations among wavelet features extracted at different time scales from the underlying time series. New correlation coefficients are further optimised with help of artificial neural networks and genetic algorithms using a nonparametric adaptive wavelet thresholding scheme. The approach is applied to the problem of pricing basket options for which the pricing formula depends on accurate measurements of correlations between portfolio constituents. When compared with standard linear approaches (i.e., RiskMetrics™), an optimised predictive wavelet correlation measure offers potentially large reductions (over 50% in some cases) in static delta-hedging errors.

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INTRODUCTION

The traditional linear correlation measure may not always be the most suitable measure of real or future correlations between returns from two financial assets (Zapart, 2003a). Although it may not be easy to quantify what the true correlation coefficient should be, it is worth trying to find a technique that would give practitioners a much better control over the process of measuring it. The choice of a particular correlation measure has important implications as the correlation coefficients are used during pricing of certain types of exotic options; for example, basket options in which the final pay-off depends on more than one underlying asset. The risk management industry also uses correlation coefficients to provide accurate Value-at-Risk (VaR) estimates to financial institutions. Correlations between share prices can also be used in conjunction with other factors when establishing long-short equity pair positions by the hedge fund industry.

Current linear approaches attempt to estimate correlations between financial assets directly from the time series (i.e., from the history of daily closing prices). The financial time series can be described as a nonstationary and nonlinear behaviour characterised by random shocks, jumps, potentially non-Gaussian noise, and lagging returns (Hazarika & Lowe, 1997; Zapart & Lowe, 1999). The presence of such artifacts is inconsistent with the basic assumptions made by linear methods that are used to estimate correlations, which may result in the financial institutions and the research community using suboptimum correlation coefficients. Moreover, existing approaches only use present instantaneous correlations (Hull, 1997, p. 480) instead of more correct future correlations that would be more appropriate when pricing basket derivatives. This issue has been addressed to some extent with the introduction of GARCH forecasts of linear correlations (Engle & Mezrich, 1996; Morgan, 1996).

Preliminary experiments reported in (Struzik & Siebes, 1999; Zapart, 2003a) have explored an alternative nonlinear approach, designed specifically to deal with the presence of nonstationarities and shocks in the time series and hence being capable of overcoming some of the limitations of current methods. The new algorithm works by looking at correlations between different wavelet features extracted from the underlying financial time series. This chapter builds upon an earlier work by Zapart (2003a) by further exploring the alternative approach and constructing appropriate feature spaces with help of techniques borrowed from such diverse fields as signal processing (discrete wavelet transform; Graps, 1995; Gençay, Selçuk, & Whitcher, 2001; Mallat, 1998), artificial neural networks (Haykin, 1994) and evolutionary programming (Holland, 1975). The approach differs from existing methods in that it tries to calculate correlations in appropriately selected feature spaces instead of operating in the time domain. By working in the feature space it is possible to separate the main signal components from random shocks or jumps and model the nonstationary and potentially nonlinear nature of financial time series, thus escaping the limitations of current methods (Aussem, Campbell, & Murtagh, 1998; Copabianco, 2002; Murtagh, Zheng, Campbell, & Starck, 1999; Zapart, 2002, 2003a, 2003b). Furthermore, by using neural networks coupled with genetic algorithms, the new approach can optimise the feature spaces by automatically discovering which features of the time series are more relevant to the calculation of the correlation coefficients. The work is strongly related to wavelet thresholding and noise reduction schemes (wavelet filtering). The crucial difference between it and existing wavelet thresholding literature
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