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Interest rates mapping

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Abstract

The present study deals with the analysis and mapping of Swiss franc interest rates. Interest rates depend on time and maturity, defining term structure of the interest rate curves (IRC). In the present study IRC are considered in a two-dimensional feature space – time and maturity. Exploratory data analysis includes a variety of tools widely used in econophysics and geostatistics. Geostatistical models and machine learning algorithms (multilayer perceptron and Support Vector Machines) were applied to produce interest rate maps. IR maps can be used for the visualisation and pattern perception purposes, to develop and to explore economical hypotheses, to produce dynamic asset-liability simulations and for financial risk assessments. The feasibility of an application of interest rates mapping approach for the IRC forecasting is considered as well.

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1. Introduction

The present study deals with an empirical analysis and mapping of Swiss franc (CHF) interest rates (IR). The complete empirical analysis includes comprehensive quantitative analysis and characterisation of daily behaviour of CHF interest rates from October 1998 to December 2005. A mapping part of the paper considers the application of spatial interpolation models for IR mapping in a feature space "maturity-date". In a more general setting interest rates can be considered as functional data (IR curves are formed by different maturities) having specific internal structures (term structure) and parameterised by econometric models.

The main questions related to the application of IR mapping are the following: (1) empirical analysis of IR spatio-temporal patterns, (2) reconstruction and prediction of interest rate curves (IRC); (3) incorporation of some economical/financial hypotheses into the IRC prediction process; (4) considering "what–if" scenario for financial engineering and risk management.

Some of the preliminary ideas elaborated in this study firstly were presented in [1], including exploratory analysis of raw and transformed data, analysis of and modelling of spatial anisotropic correlation structures (variography), feasibility study of IR mapping using deterministic and geostatistical models and short-term prediction of IR curves.

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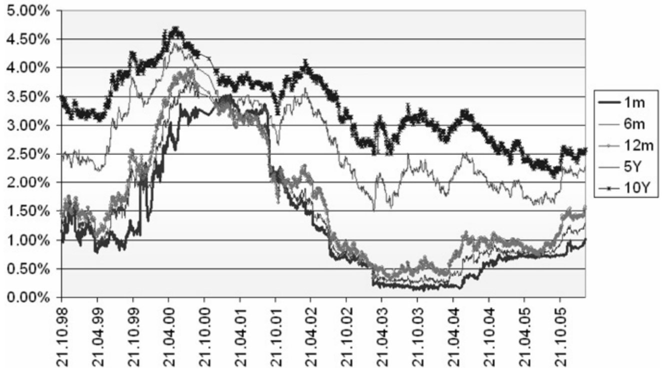

Fig. 1. Evolution of IR time series for different maturities: 1, 6, 12 months and 5 and 10 years.

In general, there are two principal approaches to make term-structure predictions [2]: (1) no-arbitrage models and (2) equilibrium models. The no-arbitrage models focus on fitting the term structure at a point in time (one-dimensional model depending on maturity) to ensure that no-arbitrage possibilities exist. This is important for pricing derivatives. The equilibrium models focus on modelling the dynamics of the intravenous rate using affine models after which rates at other maturities can be derived under various assumptions about risk premium. Detailed discussion along with corresponding references can be found in Ref. [2].

An important and interesting approach complementary to classical empirical analysis of interest rates time series was developed in Refs. [3–5] where both traditional econophysics studies (power law distributions, long range correlations, etc.) and a coherent hierarchical structure of interest rates were considered in detail.

An empirical quantitative analysis of multivariate interest rates time series and their increments (carried out but not presented in this paper) includes study of auto-correlations, cross-correlations between different maturities, detrended fluctuation analysis, embedding, analysis of distributions and tails, etc [1,5–7].

The most important part of the current study deals with an IR mapping in a two-dimensional feature space {maturity(measured in months), time/date (measured in days)} using spatial interpolation/extrapolation models: deterministic inverse distance weighting (IDW), geostatistical kriging models, nonlinear artificial neural networks (multilayer perceptron — MLP) and robust approaches based on recent developments in Statistical Learning Theory (Support Vector Regression) [8–11]. Embedding of IR data into a two-dimensional space brings us to the application of spatial statistics and its modelling tools. Higher-dimensional feature spaces can be considered and applied as well. Simple models, like linear and inverse distance weighting were used mainly for the comparison and visualisation purposes.

Evolution of CHF interest rates data is given in Fig. 1 where temporal behaviour of different maturities is presented. The IRCs are composed of LIBOR interest rates (maturities up to 1 year) and of swap interest rates (maturities from 1 year to 10 years). Such information is available on the specialised terminals like Reuters, Bloomberg, etc. and is usually provided for some fixed time intervals (daily, weekly, monthly) and for some definite maturities (in this research we use the following maturities: 1 week, 1, 2, 3, 6 and 9 months; 1, 2, 3, 4, 5, 7 and 10 years). Thus, daily IR curves considered are based on 13 maturities.

There is a coherence in the evolution of interest rate curves — not any curve can be an IRC.

This coherence can be qualitatively characterised by well known stylised facts (see below) and by rather high global correlations between different maturities. For example, coefficient of correlation between 1year and 10 year maturities is 0.8 and coefficient of correlation between 6-month and 5-year maturities is 0.88. Nevertheless, patterns of local correlations (calculated within moving or sliding windows) can be quite complex [1]. More elaborated quantitative measures to quantify temporal structures and relationships between different maturities (auto- and cross-correlations between different maturities, analysis of spread dynamics, etc.) can be applied as well.

Some typical examples of IR curves corresponding to different dates are shown in Fig. 2.

There are important stylised facts that have to be considered when modelling IR curves [2]: the average yield curve is increasing and concave; the yield curve assumes a variety of shapes through time, including upward sloping, downward sloping, humped, and inverted humped; IR dynamics is persistent, and spread dynamics is much less persistent; the short end of curve is more volatile than the long end; long rates are more persistent than short rates.