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A semiparametric factor model for CDO surfaces dynamics[☆]

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ABSTRACT

Modelling the dynamics of credit derivatives is a challenging task in finance and economics. This work studies risk of collateralized debt obligations (CDOs) by investigating the evolution of tranche spread surfaces and base correlation surfaces using a dynamic semiparametric factor model (DSFM). The DSFM offers a combination of flexible functional data analysis and dimension reduction methods, where the change in time is linear but the shape is nonparametric. The study provides an empirical analysis based on a big data set of iTraxx Europe tranches and proposes an application to curve trading strategies. The DSFM allows us to describe the dynamics of all the tranches for all available maturities and series simultaneously which yields better understanding of the risk associated with trading CDOs and other structured products.

1. Introduction

This study proposes an empirical research of a large data set of iTraxx Europe indices and their tranches of Series 2–10. We investigate around 50 000 observations of iTraxx tranches over 1000 days between the year 2005 and 2009. To the best of our knowledge, this is the first study on CDOs that considers such an extensive data set. Moreover, the dynamics of the iTraxx tranches over time has not been investigated in literature so far.

The iTraxx Europe is the most widely traded credit index in Europe. Its reference portfolio consists of 125 equally weighted, most liquid credit default swaps (CDS) on European companies. For every index five standardized tranches of different risk profiles are traded. The cash-flows structure of iTraxx tranches is the same as of synthetic CDO tranches. Because of the regular index roll, every day we find on the market tranches with various times to expiration. By plotting

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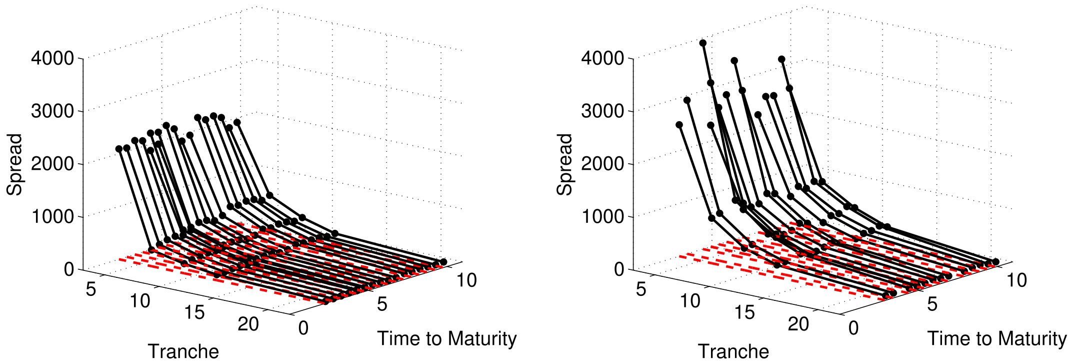

Fig. 1. Spreads of all tranches of all series observed on 20080909 (left) and 20090119 (right).

prices (base correlations) of all available tranches at one day as a function of the time to maturity and the tranche seniority, one gets a two-dimensional surface that represents the entire market information about spreads (base correlations), see Fig. 1. The tranches with 5 years maturity are the most liquid, unlike those with 3 years maturity that are rarely quoted. This makes the modelling of the surfaces a challenging task as each day one observes a different number of curves with not necessarily the same number of points on each curve. When we record these surfaces every day, we can follow how they change their shape and level. The dynamics over time of such surfaces is the main goal of this paper.

Mainly because of the high dimensionality of the CDO problem the vast majority of papers consider only CDOs of one particular maturity, see e.g. Hamerle et al. [17]. Up to our knowledge, the available literature do not look at the CDO market as a whole. Since CDOs are quoted for distinct maturities and with different liquidity, we should consider the effect of the CDO term structure.

From an investor's point of view, it is desirable to have an insight into the behaviour in the future of spreads and their main characteristics, namely base correlations. The forecasting has useful applications in hedging and trading CDOs, computation of risk measures, or construction of investment strategies. One of the simplest solutions would be to consider the classic time series analysis for each tranche of each series for every maturity. However, there are several reasons why this methodology is not applicable. Firstly, due to illiquidity of the tranche market we encounter multiple missing observations. Moreover, many iTraxx series issued during the financial crisis have too short data history. For the same reasons multivariate time series models could not find their application here. Thus, the major challenge we are facing in the analysis of iTraxx tranches is that every day only scattered observations of a two-dimensional surface are observable. This study proposes an estimation and forecasting method for CDO surfaces.

Modelling surfaces is one of the primary goals of the functional data analysis (FDA) where the data are functions, see [6]. Functional data sets naturally appear in many fields of science ranging from finance to genetics. Worth mentioning statistical approaches for handling complex high-dimensional problems are a structural analysis of curves by Kneip and Gasser [22], a functional regression with scalar (see [4]) or functional [5] response, a stochastic warping model by Liu and Müller [24], penalized splines by Kauermann et al. [21], and a functional principal components approach by Gromenko et al. [15]. For recent advances in FDA we refer the reader to Ramsay and Silverman [27], Ferraty and Vieu [13], Ferraty and Romain [12], Horváth and Kokoszka [19] and Bongiorno et al. [3]. One of the most popular methods are factor type models as they effectively reduce the dimensionality. Factor models assume that the comovements of big number of variables are generated by a small set of latent factors. When data disclose a dynamic structure then one needs a technique that is able to correctly detect and describe the observed behaviour, e.g. [16].

In this study we employ a dynamic semiparametric factor model (DSFM). In the DSFM the observed variables are expressed as linear combinations of the factors. The factors and the factor loadings are estimated from the data. The first ones represent the spatial, time-invariant component. The latter ones form multidimensional time series that reflect the dynamics. The inference on the original variables reduces to the inference on the factors and the factor loadings. For advances in semiparametric functional data modelling we refer reader to Goia and Vieu [14].

The DSFM was introduced by Fengler et al. [11] for modelling the dynamics of implied volatility surfaces. Further, Härdle [18] use it for limit order book analysis, Detlefsen and Härdle [8] for variance swaps, and van Bömmel [30] for fMRI images. In this work we study the dynamics of CDO surfaces with the DSFM and propose an application to curve trading strategies.

The paper is structured as follows. Section 2 discusses the CDOs. Section 3 describes the DSFM. Section 4 shows results of the empirical modelling. Section 5 presents applications in CDO trading. Section 6 concludes.

2. Collateralized debt obligations

A collateralized debt obligation is a credit derivative used by financial institutions to repackage individual assets into a product that can be sold to investors on the secondary market. The assets may be mortgages, auto loans, credit card debt,