MODELLING CDS PRICE DYNAMICS FOR DETERMINATION OF MARGIN REQUIREMENTS

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This paper reviews the difficulties concerning the development of single-name CDS price (spread) dynamics model for the purpose of determination of margin requirements. It also discusses a possibility to construct such a model using information about respective equity prices and option implied volatilities. Finally, it presents the basic step towards the former idea demonstrating results for the CDS written on a Gazprom senior debt.

Keywords: credit default swaps, counterparty risk, market risk, margin requirements, modeling price dynamics.
JEL classification: C18, G13

INTRODUCTION

The recent financial crisis has revealed the particular weaknesses of CDS (*credit default swap*) market. The major feature of CDS contracts which led to troubles during the crisis was a counterparty risk which is very unevenly distributed between counterparties. A protection buyer is more exposed to the default of counterparty, because a payment, which protection seller is obliged to make, is lump, contingent and potentially large, whereas a CDS buyer benefits from credit event and pays regular relatively small amounts.

In order to mitigate a counterparty risk a CCP (*central counterparty*) was introduced for CDS transactions. The main instrument, which any CCP uses to manage counterparty risk exposure on a daily basis, is a system of margin requirements. To build a solid and consistent system of margin requirements an accurate model of CDS prices dynamics is necessary.

Unfortunately, creating such a model is a rather complicated task because of features of CDS market functioning, CDS structure and relatively short history of market existence. Meanwhile results obtained with many standard and tractable approaches, as model-independent or reduced-form, might be unsatisfactory.

A possible way to get over those problems is applying of structural approach using relevant information from other markets, e.g. equity or derivative markets, and reflecting key patterns between those markets and CDS one.

ISSUE OVERVIEW

The CDS market was an opaque over-the-counter market, where dealers quoted bid and ask prices and minimum volume for their clients. They published some quotes through different financial information services such as Bloomberg, Thomson Reuters or Markit, which may aggregate those quotes in a single time series.

Being the most active and liquid segment of credit derivative market, CDS one still lacks for liquidity and speed comparing to equity and some derivative markets. Generally only daily CDS market data is available for analysis. Indeed, dealers do not disclose their trading books, thus, studying trading process in CDS market cannot be conducted.

Since April 2009 when CCP was introduced to CDS market several significant conventional changes have been undertaken in order to provide transparency and standardization. Furthermore, created CCPs have been given access to trade information in order to develop their own systems of margin requirements. But information is still being gathered and there is no best practice to refer to. In these circumstances approaches to the determination of margin requirements and modeling CDS price dynamics are open to question.

Several techniques may be applied to a description of CDS price dynamics.

Model-independent approach obtains the process of spread dynamics by constructing an empirical distribution of price. Further, the empirical distribution function can be accurately approximated by the analytical function of any kind. Such approach fails in a case of CDS market. Firstly, over a last decade CDS market structure has changed several times significantly, thus, data gathered over that time cannot be considered as homogenous. Any results may be drastically biased if this approach is applied to a data set consisting of elements from different regimes. Finally, single-name CDS spreads tend to cluster due to entities' tendency to have the same credit rating over quite long time and to change gradually in terms of credit quality. So it's impossible to outline a sample set of CDS spreads for any given CDS contract.

Reduced-form models came from an interest rate modeling field. This approach threats a moment of credit event as absolutely unpredictable one. Under assumptions that default intensity follows some process and that CDS is priced on par under the risk-neutral probability measure reduced-form models are to be calibrated on CDS spread term structure to fit it the best way. The problem is that tractable models of this class with few degrees of freedom are unable to replicate correctly both a term structure of CDS spread and its dynamics. In order to avoid such a problem the number of freedom degree might be increased at the cost of tractability. Moreover, reduced-form models, especially with a significant number of stochastic factors, are subject to a "curse of dimensionality", if it applies to a determination of margin requirement for a portfolio of CDS.

Within a **structural approach** the intrinsic mechanism of default is to be modeled. It estimates a default distribution using information about entities' capital structure and considers equity and debt as derivatives representing a contingent claim for entity's assets. It implies that option-pricing techniques are applicable to CDS pricing and risk-neutral probability measure may be assessed endogenously. The imperfection of structural approach is its disposition to underestimate a credit risk on the short horizon and predict too low short-term credit spreads. However, it reproduces credit spread dynamics rather well and frequently in a leading manner.

Such property of structural approach as leading is due to incorporation in modeling process equity and equity derivative information, which often outpaces CDS spread changes. Thus, the model based on structural approach is expected to produce margin requirements able to absorb any losses on a timely basis.

EQUITY AND CDS MARKET RELATION

The literature concerning an empirical and thorough investigation of interdependence between CDS and equity is quite recent. Papers such as Cao, Zhong, Yu (2009) and Tang, Yan (2010) found that implied volatilities and stock prices usually outstrip CDS spreads and have a rather high explanatory power. It is consistent with economic intuition that stock and option markets outstrip CDS market in a price discovery process because of significant presence of noise traders and greater liquidity, which allows informed traders to incorporate their private information into prices much easier and faster. Another study Raunig, Scheicher (2008) documented that the market risks of stocks are typically greater than of CDS contracts, but they converge with a credit worthiness downgrade of reference entity. Therefore, it is expected that using information from equity and option markets, if it is available, we can obtain predictions of CDS price changes which are conservative enough to be a base for margin requirements.

We also conduct our own data observation. Studying a stock price and CDS spreads for corporate entities with different credit rating, we found that the higher credit rating of considered entity, the greater ratio of relative increments of CDS spread and equity returns (elasticity). This observation indicates that CDS spread may exponentially depend on the stock price. Of course, it is not so simple, but at least it is reasonable to require this property from a spread dynamics model.

APPLICATION OF STRUCTURAL APPROACH

This section presents a preliminary attempt to apply a structural approach to determination of margin requirement for an individual single-name CDS contract. The basic idea, underling the study described further, consists in the following: using a joint model of stock price and an implied volatility dynamics to obtain potential future stock prices and levels of volatility and transforming these projections into potential future CDS spreads. In this framework margin requirement may be calculated as a difference between the quintile of future CDS spread distribution and the current spread volume.

CDS pricing was conducted with the CreditGrades model (see Finger et al. (2002)), which is a fist-passage structural model with stochastic default barrier. The reasons of picking this model were its relative tractability and consistency with observed short-term credit spread levels. It requires such inputs as a stock price, debt-per-share, future stock volatility, zero-coupon yield curve and CDS maturity date. Other parameters (recovery rate and variance of default barrier level) are to be calibrated on the current market CDS spread data or assumed.

The SABR model (Hagan et al. (2002)) which is a stochastic volatility model was implemented to generate future stock prices and implied volatilities. According to its assumptions forward price of asset satisfies the following stochastic equations:

$$dF_t = \alpha_t F^{\beta} dW_t^1$$

$$d\alpha_t = \upsilon \alpha_t dW_t^2$$

$$E(dW_t^1 dW_t^2) = \rho dt$$

where F_t - forward asset price, α_t - volatility-like variable, ρ - correlation parameter, β and υ - constant parameters, W_t^1 and W_t^2 - standard Brownian motions.

This model allows estimating the ATM volatility from a futures option book and quite accurate modeling its future levels. It also describes patterns of volatility smile and leverage effect. Noticing that volatilities of stock and stock futures prices are usually very close, we consider implied volatility of futures as satisfactory estimate of future stock volatility.

We demonstrate the results of implementation of this method by example of CDS written on Gazprom senior debt denominated in USD. We used respective stock prices and futures implied volatility as inputs to calibrate a SABR model and simulate changes of stock prices and implied volatilities over next day. It's noteworthy that the risk associated with interest rate changes is not considered in this study for the purpose of simplicity and because it's effect is expected to be minor.

To compare performance of this approach during soft and stress periods, the initial time span was split in two sub-periods: pre-crisis (at least for Russia) and crisis ones.

Fig.1 illustrates results for a pre-crisis sub-period. Upper and down 99% confidence one-side boundaries are alike but not perfectly symmetric, thus, implying a greater risk for a CDS buyer. Both boundaries have been hit three times each (*red bars*) and that is a satisfactory result, because the entire data set amounts to 339 observations.

Fig.1. Gazprom CDS spreads daily increments (black bars) and 99% confidence one-side quintile boundaries (blue lines) (10.2007 – 07.2008)

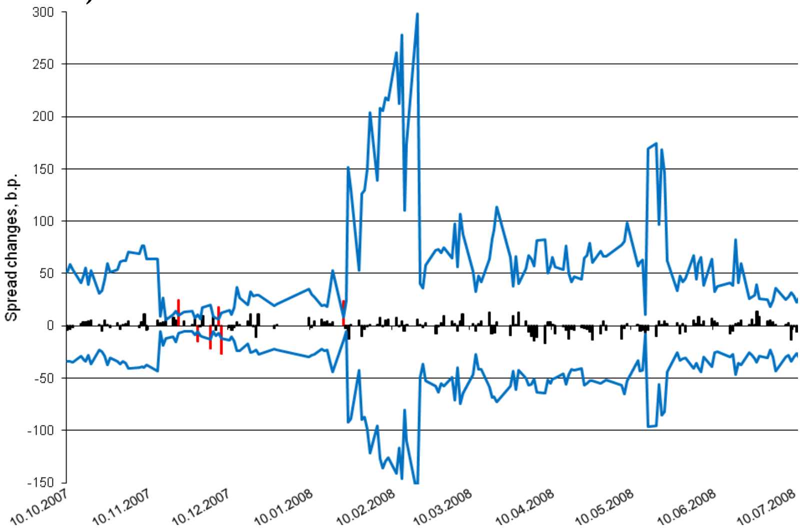
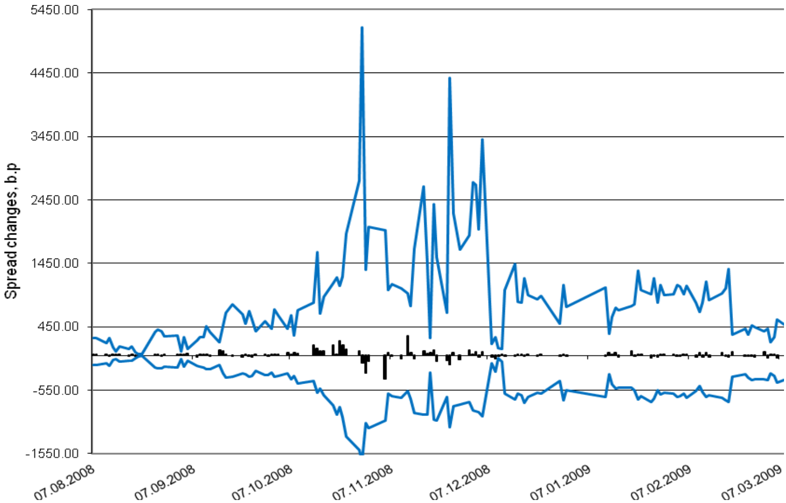


Fig.2 covers results for a crisis period. Two things are noteworthy concerning this figure. Firstly, since beginning of October 2008 boundaries had rapidly and significantly widened, as a market panic strengthened and volatility of CDS spreads increased. That time CDS spreads were above 1000 b.p. level and reached 1760 b.p. at the peak. Finally, the boundaries have never been hit during the crisis period, thus, providing conservative risk measures.

Fig.2. Gazprom CDS spreads daily increments (black bars) and 99% confidence one-side quintile boundaries (blue lines) (08.2008 – 04.2009)



These results might be easily recalculated in terms of the up-front payment, which is a current convention of trade execution at the CDS market.

As for performance of the method on the entire sample, obviously, it performs too conservatively. Indeed the method requires further development, e.g. to formalize how to switch from an option of one maturity to another in order to avoid leaps of boundaries in such switching points.

But being really conservative, such method based on a structural approach to credit risk pricing might be considered as a benchmark in terms of CCP's objective to provide safety to the trade execution and the settlement process. The method also has to be tested in a case of defaulted entity in order to complete its performance assessment.

CONLUSION

In this paper we have discussed difficulties concerning the development of a single-name CDS spread dynamics model for the purpose of determination of margin requirements.

We have also briefly overviewed recent papers studying a relation between CDS and equity markets. Those studies documented the existence of interdependence between CDS and equity and described a series of patterns. We have conducted our own analysis and also found a pattern between a ratio of relative increments of CDS spread and equity returns (elasticity) and entity's credit rating.

Finally, we have made an attempt to roughly test performance of the method of determination of margin requirements based on the structural approach. It was applied to CDS written on a Gazprom senior debt denominated in USD. Obtained results have shown that method performed very conservatively, but it may be used as benchmark in terms of potential losses coverage. Meanwhile, the considered method requires a further development and an assessment of its performance in a case of defaulted entities.

Referances

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FINANCIAL MARKET SIMULATIONS

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Agent-based simulation has emerged as a promising research alternative to the traditional analytical approach in studying financial markets. The idea behind agent-based simulation is to constructively model a market in a bottom-up fashion using artificial agents. Under the umbrella of Market Microstructure Project (MMP), a Prognoz Risk Lab initiative, financial market simulations is a major attempt to construct an agent based