



## Price discovery of credit spreads in tranquil and crisis periods<sup>☆</sup>

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### ABSTRACT

In this paper we investigate the price discovery process in single-name credit spreads obtained from bond, credit default swap (CDS), equity and equity option prices. We analyse short term price discovery by modelling daily changes in credit spreads in the four markets with a vector autoregressive model (VAR). We also look at price discovery in the long run with a vector error correction model (VECM). We find that in the short term the option market clearly leads the other markets in the sub-prime crisis (2007–2009). During the less severe sovereign debt crisis (2009–2012) and the pre-crisis period, options are still important but CDSs become more prominent. In the long run, deviations from the equilibrium relationship with the option market still lead to adjustments in the credit spreads observed or implied from other markets. However, options no longer dominate price discovery in any of the periods considered. Our findings have implications for traders, credit risk managers and financial regulators.

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### 1. Introduction

An extensive literature shows the impact of credit risk on bond prices (early contributions in this area are Fisher, 1959; Johnson, 1967; Merton, 1974; Sarig & Warga, 1989, among others) and recent research has started to single out and analyse a credit risk factor in stock prices (Chava & Purnanandam, 2010; Dichev, 1998; Vassalou & Xing, 2004). The important role of credit risk in security prices has also led bank regulators to introduce new capital requirements that reflect the potential for credit risk related losses in traded instruments.<sup>1</sup> In the light of recent events, it is important for financial economists, traders and regulators to identify the markets that incorporate credit risk related information most quickly and lead other markets in the price discovery process. Such information may

give an early warning on imminent and possible large shocks in asset prices.<sup>2</sup> In addition, an understanding of the transmission mechanism of credit risk information across markets and its evolution over time may shed light on the relative efficiency of the markets and on the way their role changes in different market conditions. In this paper we investigate the discovery of the price of credit risk in the bond, CDS, stock and option markets over the period 2006–2012.

The credit risk associated with a company may be measured in the credit market, via the credit spread of bonds issued by that company and via the price of CDSs written on those bonds. Indirectly, credit risk can also be quantified through implied credit spreads. Based on Merton (1974), Kealhofer (2003a,b) and Vassalou and Xing (2004) show how information on credit risk can be extracted from equity prices. Hull, Nelken, and White (2005), Stamicar and Finger (2006) and Cao, Yu, and Zhong (2011), on the other hand, show how to use the price of options written on a firm's stock to obtain implied credit spreads.

Several papers look at price discovery in the bond and CDS markets (e.g. Blanco, Brennan, & Marsh, 2005; Zhu, 2006) and bond, CDS and stock markets (Forte & Peña, 2009; Longstaff, Mithal, & Neis, 2003; Norden & Weber, 2009). However, the role of the option market in the price discovery of credit risk has attracted less attention. Recent research has found that the implied volatility of options written on stocks or stock futures can help explain credit spreads (Alexander

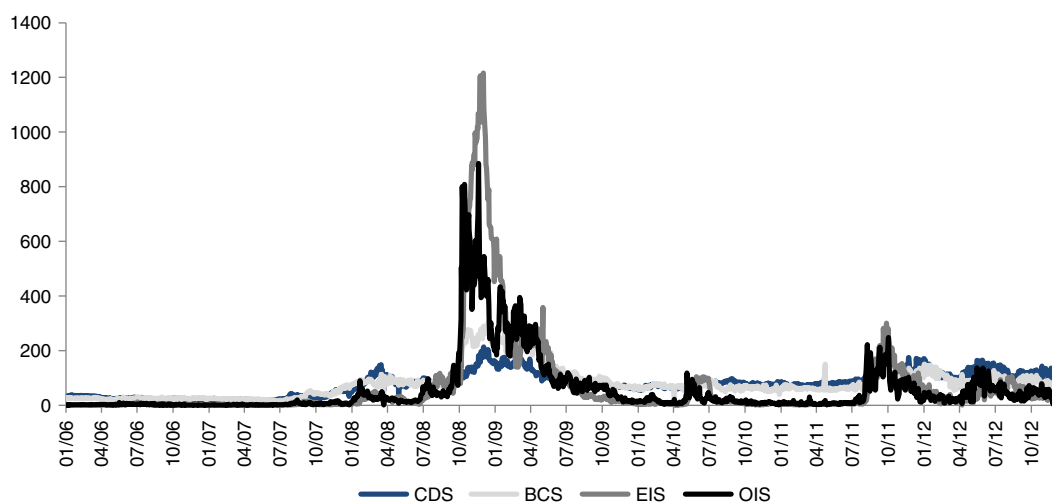
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<sup>1</sup> In order to cope with increased migration risk, default clustering and loss of liquidity in crisis periods (which may negatively affect corporate bond prices as well as equity prices, among other securities), bank regulators have introduced an additional capital requirement for trading securities, namely the incremental risk charge (IRC), which is based on a 1-year risk horizon and a 99.9% confidence level for value-at-risk estimations, similarly to the capital requirements on non-trading bank loans (Basel Committee on Banking Supervision, 2009).

<sup>2</sup> For example, Hamalainen et al. (2012) show how the market prices of credit default swaps, subordinated debt and equities and the implied volatility from option prices were useful early warning indicators of the financial problems at Northern Rock, which was eventually bailed out in September 2007.



**Fig. 1.** Time series of credit spreads. This figure shows time series of daily cross sectional median spreads obtained from the credit default swap market (CDS), the bond market (BCS), the equity market (EIS) and the option market (OIS) during the period 2006–2012.

& Kaeck, 2008; Berndt & Ostrovnaya, 2008; Cao, Yu, & Zhong, 2010; Collin-Dufresne, Goldstein, & Martin, 2001; Cremers, Driessen, Maenhout, & Weinbaum, 2008). This is not surprising as banks and hedge funds routinely implement arbitrage trading strategies that are based on the discrepancies between the credit spreads implied from equity options and the spreads of bonds and CDS contracts for individual firms as shown in JPMorgan (2006) and Kapadia and Pu (2012).<sup>3</sup> In particular, Kapadia and Pu (2012) find that equity and credit markets co-move and are fairly integrated over the long run. This suggests that, from the point of view of our analysis, they are both expected to have a significant role in the price discovery of credit risk. However, they also show that, in the short run, pricing discrepancies between equity and credit markets may persist because of constraints to arbitrage (such as liquidity and idiosyncratic risk). The implication is that an analysis of price discovery in the short run and long run may lead to different results.

Based on previous findings, we expect CDS, bond, equity and option spreads to contribute to the price discovery of credit risk, and their informative role to be dependent on various factors related to the trading conditions that characterise each market. To the extent that information is incorporated into securities' prices through trading activity, a strong link should exist between price discovery and trading-related variables such as trading volumes, bid-ask spreads and volatility. We would expect this pattern to differ in the pre-crisis and crisis periods, due to the effect the crisis had on the previously mentioned trading-specific variables. Chakravarty, Gulen, and Mayhew (2004) investigate the price discovery in stock and option prices and find that price discovery is associated with high trading volume and narrow bid-ask spreads. Given our lack of data on trading volumes and transaction prices for all securities under analysis, we are unable to investigate the changing nature of trading activity in each market (which determines the changing patterns of price discovery documented in our work). We then limit our study to an investigation of the important empirical question of which market most timely incorporates credit-related information.

We add to the existing literature by (1) analysing, for the first time, all the markets that may contribute to the price discovery of credit risk, namely the bond, CDS, equity and option markets; (2) performing our analysis over an extended sample period including the 2007–2009

sub-prime crisis and the 2009–2012 sovereign debt crisis, which allows us to investigate changes in price discovery under different market conditions. We find that when we employ a vector autoregressive model (VAR) on daily credit spread changes to look at the price discovery in the short term, the option market clearly leads the others in the sub-prime crisis, that is the period of highest uncertainty in our sample (see Fig. 1). However, during the less severe sovereign debt crisis (2009–2012) and the pre-crisis period, though options are still important, CDSs become the most prominent market. Interestingly, when we use a vector error correction specification (VECM) and consider how credit spreads adjust to deviations from long run equilibrium relationships, options still influence other markets but no longer have a prominent role regardless of market conditions. We conclude that during periods of pronounced market dislocation, credit spreads react not only to shocks first registered in the option market but also to deviations from long term trends that are better captured in the other markets. Specifically, the CDS and equity markets lead the long run price discovery of credit spreads during both the pre-crisis period and the sovereign crisis period. However, the bond market becomes more influential in the sub-prime crisis and especially for the European sample of firms, where it appears to be the leading market. In our US sample, the CDS market leads long run price discovery during the sub-prime crisis.

Our findings should be of interest to various market participants. Policymakers, concerned about the stability of the whole financial system, should benefit from a better understanding of how equities, bonds, options and credit derivatives are interlinked during periods of high and low volatility. Also, understanding which market contributes the most to price discovery becomes crucial to provide timely responses to systemic crises. Hedgers and arbitrageurs are also clearly interested in receiving the earliest possible signals of credit risk reversals.

The remainder of the paper is organised as follows: Section 2 reviews the related literature on credit risk price discovery. Sections 3 and 4 describe the data and our methodology. In Sections 5 and 6 we discuss the main results and robustness tests. Section 7 concludes.

## 2. Literature review

The literature on price discovery in credit spreads is relatively recent. Zhu (2006) analyses CDS and bond spreads and finds that CDSs lead price discovery in the US market. Another study on the relationship between the bond and CDS markets in Europe and the US is that of Blanco et al. (2005), concluding that the CDS market is responsible, on average, for about 80% of price discovery over their sample period.

<sup>3</sup> These strategies do not ensure riskless profits as the traditional meaning of arbitrage implies, hence they are referred to as "risky arbitrage".

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