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Explaining credit default swap spreads by means of realized jumps and volatilities in the energy market

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ABSTRACT

This paper studies the relationship between credit default swap (CDS) spreads for the Energy sector and oil futures dynamics. Using data on light sweet crude oil futures from 2004 to 2013, which contains a crisis period, we examine the importance of volatility and jumps extracted from the futures in explaining CDS spread changes. The analysis is performed at an index level and by rating group; as well as for the pre-crisis, crisis and post-crisis periods. Our findings are consistent with Merton's theoretical framework. At an index level, futures jumps are important when explaining CDS spread changes, with negative jumps having higher impact during the crisis. The continuous volatility part is significant and positive, indicating that futures volatility conveys relevant information for the CDS market. As for the analysis per rating group, negative jumps have an increasing importance as the credit rating deteriorates and during the crisis period, while the results for positive jumps and futures volatility are mixed. Overall, the relation between the CDS market and the futures market is stronger during volatile periods and strengthened after the Global Financial Crisis.

1. Introduction

The seminal work of Merton (1974) investigates the intrinsic relationship between credit risk, equity volatility and equity returns. It underpins the negative correlation between stock movements and credit risk, as well as the positive correlation between stock volatility and credit risk. Following this work, many empirical studies have analyzed the interactions between these three quantities. Most of them focus on finding the determinants of credit risk using several financial variables, including stock volatility and stock returns. These variables are confirmed to be important, which is consistent with Merton's intuition; see among others Collin-Dufresne et al. (2001) and Campbell and Taksler (2003). Credit risk was initially measured by bond yield spread while equity volatility was obtained by using mean squared log-returns. The evolution of financial markets led to a reassessment of this intrinsic relationship between credit risk, equity volatility and equity returns. In particular, the rise of the credit default swap (CDS) market has provided an alternative way of quantifying credit risk whereas options provide a more forward looking point of view of equity volatility; see Benkert (2004) and Ericsson et al. (2009).

During the past decade equity volatility has become an asset class by itself, with the VIX being the most prominent example. Nowadays, volatility derivatives, including simple futures contracts as well as more sophisticated option contracts written on volatility indices, are actively traded. In the credit market, the credit default swap (CDS) serves as the underlying asset for options, which include collateralized debt obligations (CDOs) and other complex products (first-to-default, N-to-default and alike). The close relationship between these markets was strikingly illustrated during the Global Financial Crisis (GFC). It also led to many research works on contagion and market linkages. The increasing complexity of financial derivatives and their interconnection urges the need for a consistent modeling framework for credit risk, stock return risk and stock volatility risk. So far, only a few research papers have addressed this important task. These include Carr and Wu (2007) who propose a model for joint dynamics of the stock with stochastic volatility and credit

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default intensity[3] that allows for a consistent pricing of stock options and CDS. The authors estimate the model by calibrating simultaneously time series of options and credit default swap spreads. They obtain rather puzzling results suggesting that default intensity is negative, and that there is a negative correlation between stock volatility and default intensity. Both results are inconsistent with Merton's framework. We note that the authors link the default intensity and the stock dynamics through the stock jump intensity (i.e. the stock jump arrival rate affects the default intensity) but the stock jump itself has no impact on the CDS market. A slightly different model was later proposed in Carr and Wu (2010) but it also leads to puzzling conclusions. Indeed, the authors find a zero correlation between default intensity and stock volatility, and a closer look at their results leads to an even more problematic conclusion as they find that stock/volatility dynamics are completely unrelated to the CDS intensity. Thus, a complete contradiction with Merton's results.

These results are also problematic from a practical point of view as equity derivatives and more precisely put options are often used as a credit derivatives. Along that line, let us mention the works of Cao et al. (2011) and Carr and Wu (2011) among many others. The lack of a consistent pricing framework for both credit and equity risks therefore results in failure to manage the financial risk appropriately; and taking into account the size of these markets, it raises the question of the overall derivative market stability.

In light of these results it appears to us that the definition of a consistent model for the stock market, the volatility market and CDS market has not yet been established, and the results obtained so far might be either due to a model misspecification and/or numerical/computational difficulties arising when implementing the models. In fact, both aforementioned papers (Carr and Wu (2007, 2010)) involve challenging numerical algorithms that can jeopardize the estimation procedure. Regarding model specification problems, both papers establish the link between the stock-volatility market and CDS market through the relationship between the stock jump *intensity* (i.e. stock jump arrival rate) and the default intensity, rather than linking the stock jump *size* to the default intensity. Thus, maybe linkages between these two markets should be performed through jump sizes rather than jump intensity or jump times. Financial asset jump activity has always been considered as an important component of asset dynamics; see Merton (1976) or Bates (2000). Availability of high frequency data along with econometric works (see e.g. Aït-Sahalia (2002, 2004), Barndorff-Nielsen and Shephard (2004, 2006)) has enabled further insight into investigation of the price components. The results of Carr and Wu (2007, 2010) could possibly be explained by an underestimation of the role of jumps in market linkages as none of these models exhibit this property.

The existing literature provides a convenient framework to analyze the joint dynamics of stock returns, stock volatility and credit risk along with the role of stock jump activity. Indeed, Zhang et al. (2009) examine to what extent equity jumps and volatility are able to explain CDS spreads. Performing a panel analysis on a sample ranging from January 2001 to December 2003 for 307 U.S. firms, the authors find that equity volatility given by the bipower variation is an important determinant of CDS spread changes. Beyond stock returns, stock volatility and stock jump activity, they also consider macro-variables and accounting variables. Surprisingly, these authors find that equity jumps, either positive or negative, as well as jump intensity and jump volatility, are not significant when explaining CDS spread changes.[4] Although they conclude that jumps are irrelevant the considered dataset, their framework, restricted to CDS spread, stock volatility and stock jumps, can be used to evaluate how market linkages depend on jump activity.

Our work contributes to the literature by introducing the first comprehensive analysis of the relationship between CDS spread for the Energy sector and oil futures jump and volatility activities. As opposed to previous studies performed for equity markets, our sample is large, ranging from January 2004 to December 2013, and contains both low and high volatility periods allowing to determine how market conditions affect this relationship. We perform the analysis for the CDS spread at an index level and per rating group, thus assessing the impact of creditworthiness on this relationship. We also split the sample into pre-crisis, crisis and post-crisis periods. Our results are consistent with Merton's theoretical framework. At an index level, we find that futures jumps are an important ingredient when explaining CDS spread changes, with negative jump components having higher impact during the crisis period. Furthermore, we find that the continuous volatility part is significant and positive indicating that futures volatility conveys relevant information for the CDS market. As for the results per rating group, we find that negative jumps have an increasing importance as the credit quality deteriorates, as well as during the crisis period. We observe mixed results for the significance of positive jumps and futures volatility when looking across different rating categories and various sample periods. Overall, the relation between the CDS market and the futures market appears to be stronger during volatile market conditions and strengthens after the GFC.

The paper is organized as follows. We present the key ingredients for the jump detection framework in Section 2. A description of the empirical data used in our analysis is provided in Section 3. Regression tests and analysis are performed in Section 4. Section 5 provides consistent model perspectives and Section 6 concludes the paper.

2. Model specification

Let $s_t = ln(S_t)$ be the log-asset price whose dynamics evolve under the influence of a jump-diffusion process

$$ds_t = \mu_t dt + \sigma_t dW_t + J_t dq_t, \tag{1}$$

where μ_t and σ_t are the instantaneous drift and diffusion terms of the return process, respectively; J_t is the log jump size with mean μ_J and standard deviation σ_J, W_t is a standard Brownian motion and dq_t is a Poisson process with intensity λ_J[5]. Time is measured in daily units and we define the intraday returns as

$$r_{t,\, i} = s_{t,\, i \cdot \Delta} - s_{t,\, (i-1) \cdot \Delta}, \tag{2}$$

[3] In the first order approximation CDS spread can be approximated by credit default intensity.

[4] In the following we will be also referring to Tauchen and Zhou (2011) and Wright and Zhou (2009) who investigate the explanatory power of jumps, either for bond yield spreads or bond excess returns, but do not consider the CDS market. Notice also the works on WTI crude oil futures contracts by Sévi (2014, 2015), with the former underlining the role of jumps to forecast volatility while the latter focuses on convenience yield. The work of Naifar (2012) considers the relationship between CDS spreads and jumps but within a very different mathematical framework, namely, using copulas.

[5] As mentioned above, jump diffusion models have a long history in finance. More specific to the commodity market, recent works underpin the importance of jumps (see Larsson and Nossman (2011), Chevallier and Ielpo (2012) and Brooks and Prokopczuk (2013)); find that intensities for commodity price jumps are time varying (refer to Diewald et al. (2015)); and underline that jumps have important consequences in risk management (Chen et al. (2013), when considering jumps as a modeling strategy for extreme events).