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Paper

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First Significant Digits and the Credit Derivative Market during the Financial Crisis

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First significant digits and the credit derivative market during the financial crisis

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In this letter we discuss the Credit Default Swap (CDS) market for European, Indian and US CDS entities during the financial crisis starting in 2007 using empirical First Significant Digit (FSD) distributions. We find out that on a time aggregated level the European and the US market obey empirical FSD distributions similar to the theoretical ones. Surprising differences are observed in the development of the FSD distributions between the US and the European market. While the FSD distribution of the US derivative market behaves nearly constant during the last financial crisis, we find huge fluctuations in the FSD distributions in the European market. One reason for these differences might be the possibility of a strategic default for US companies due to Chapter 11 and avoided contagion effects.

I Introduction

The financial markets and the world economy as a whole are currently beset by high uncertainty. What was sparked by a decrease of housing prices in the US, led in the end to a near collapse of the global credit markets. In this letter we use empirical FSD\(^1\) and theoretical Benford-like distributions (Benford, 1938; Grendar et al., 2007) to study the CDS market during the financial crisis, which started in July 2007. The reasons to choose the CDS market as a representative of the credit market are twofold: Firstly, before the crisis the CDS market was often lauded as an over-the-counter (OTC) market with prodigious risk-transferring ability which stabilizes the financial system as a whole (Greenspan, 2005). Secondly, from being a fledgling market in the mid nineties, the CDS market has grown tremendously over the last decade (Dechert LLP, 2008), and is apparent an integral part of the financial system.

The main findings in this work are twofold: Firstly, we illustrate the usefulness of FSD distributions to check the “quality” of such data “in some vague sense” (Varian et al., 1972; George and Laura, 2009). Especially for the CDS market this is essen-

\(^1\)In the following we refer to empirical FSD distributions simply as FSD distributions.
tial because it is a decentralized OTC market and is often pictured as an opaque market with little information about the pricing mechanism, price setters and traded volumes. We find out that for Europe and the US, the first digits follow patterns of FSD distributions similar to the proposed Benford-like FSD distribution, i.e., the appearance of the first digits follow a weakly monotonic decreasing pattern, as provided by [Benford, 1938]; [Grendar et al., 2007]. For the Indian market, we observe FSD distributions which strongly deviate from the theoretical one. This might be a hint of “distorted data” (George and Laura, 2009).

Secondly, provided with daily data, we are interested in the development of the FSD distributions during the financial crisis 2007. Here we find huge differences between the FSD distribution of US companies and European ones. Quite surprisingly, for US companies the FSD distribution of the CDS spreads remained nearly stable during the financial crisis. This poses the question why the CDS market of this region – which was the origin of the financial crisis – is in terms of FSD distributions more stable than the European market.

This article is organized as follows: The next section briefly reviews the literature on FSD distributions and the CDS market. Then we will describe our data. Thereafter we present the main results of this letter. Finally conclusions and discussions about further research follow.

II Benford’s Law, Benford-like Distributions and the CDS Market

Benford’s Law ([Benford, 1938]) is an unexpected mathematical relationship that states that the FSDs of numerous examples of data follow a specific distribution and are not uniformly distributed as one could expect. It postulates that the probability that the first digit is $i \in \{1 \ldots 9\}$ is given by $p(i) = \log_{10}(1 + 1/i)$. E.g., the 1 appears with about 30.1% and the 9 only with 4.6% as the first digit. Nearly 60 years later, [Hill, 1995] provides a rigorous proof of this law as well as conditions under which it holds. Today there is a wide range of data sets which have been tested according to Benford’s Law, e.g., [Giles, 2007]; [Depken, 2008]; [Günzel and Tödter, 2009] or [Ley, 1996]. Ley (1996) for example finds that 1-day returns of the S&P 500 reasonably agree with Benford’s Law. Huge deviations from it are often interpreted as signals of some type of irregularity like psychological price barriers or price collusions (Ceuster et al., 1998; Giles, 2007). But the literature also shares the common result that we rarely find a perfect match of the observed FSDs to Benford’s Law. Therefore [Grendar et al., 2007] propose an information theoretic approach, based on the first moments of the empirical FSDs, to derive modifications of the Benford distribution – Benford-like distributions. The idea of the approach proposed by [Grendar et al., 2007] is to estimate a probability distribution $P$ which minimizes the Kullback-Leibler distance to the Benford distribution and has a first moment which equals the empirical FSD mean. Distributions for different first moments of FSDs are tabulated in [Grendar et al., 2007]. The resulting Benford-like distribution $P$ provide a null distribution for testing empirical FSD distributions.

There is a broad literature analyzing the CDS market, e.g., [Forte and Peña, 2009]; [Longstaff et al., 2005]; [Realdon, 2008]. Jorion and Zhang (2007) study contagion effects in the CDS market due to Chapter 11 and Chapter 7 events.

Building up on the work of Ley (1996), who studied the stock market using Benford’s Law and on Realdon (2008), who linked the CDS market to the stock market, we study the CDS market using FSD and Benford-like distributions.

III Data

As a basis to illustrate the distribution of the FSDs and to check the appropriateness of FSD distributions to study the OTC market, we use daily Markit CDS data for European, Indian and US companies. Markit is one of the leading data provider which is specialized on pricing credit derivatives. According to Markit the CDS spreads do not represent the actual traded spreads but each contributor to
Markit provides the data from its books of record and/or automated trading systems. The offered Markit CDS spreads are composites of these different sources \cite{Markit Group Limited, 2008}. In this work we use daily CDS spreads in basis points (bpts.) for European, Indian as well as US companies which are on the run from 2006-08 to 2010-02. We are provided with spreads for 11 different maturities ranging from 6 months to 30 years.

In addition to the basic CDS contract terms such as maturity, sector & issuer, CDS contracts often come in four different flavors according to their restructuring mechanism (no restructuring, full restructuring, modified restructuring, or modified-modified restructuring). The Markit data set contains CDS spreads in all four different restructuring versions. For studying FSD distributions we did not exclude any of these restructuring mechanisms. Our time series runs for 868 days, which results in a total of $\sim 1.44 \times 10^8$ CDS spread observations. For the different regions, we observe on average daily 78,289 observations for European companies, 1,054 for Indian and 88,346 for US ones. Table 1 summarizes some descriptive statistics of the CDS spreads for the two largest markets – the European and the US market. It contains the observed means, medians and standard deviations for the considered time series. We split the data into two categories, investment CDS entities and subinvestment CDS entities. The first group contains entities with a credit rating of at least A and the second group contains all CDS entities which are rated worse than A.

<table>
<thead>
<tr>
<th></th>
<th>Investment</th>
<th>Subinvestment</th>
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<tbody>
<tr>
<td></td>
<td>Europe</td>
<td>US</td>
</tr>
<tr>
<td>Mean CDS spread</td>
<td>79.778</td>
<td>83.095</td>
</tr>
<tr>
<td>Median CDS spread</td>
<td>66.976</td>
<td>57.456</td>
</tr>
<tr>
<td>Standard Deviation of CDS spreads</td>
<td>49.598</td>
<td>73.086</td>
</tr>
</tbody>
</table>

**IV Results**

**Reasonability of the data:** In order to check the quality of our data, we use the approach proposed by Grendar et al. \cite{Grendar et al, 2007}. Fig. 1 presents rootograms for the aggregated daily FSD distributions of the US (left), the European (middle) and the Indian (right) CDS entities. The observed proportions are displayed as bars, “hanging” on the estimated Benford-like distributions $P$ which are calculated on the basis of the observed FSD means for the different regions.

As we can see for the first two markets the FSD distributions are very similar to the theoretical ones. For the Indian market we observe much more higher digits (6 to 9) than predicted by the estimated distribution. Along the lines of George and Laura \cite{George and Laura, 2009} this might be an indication of distorted data.

For all three markets, statistical tests like a $\chi^2$-test or Kuiper test would reject the null-hypothesis because of the huge power that any of these tests have given the large sample size. If one takes models as approximations to reality, instead of perfect data reproducers, this can be seen as a weakness of Neyman Pearson statistics \cite{Ley, 1996}. For sample sizes $N$ less than 5000 observations we would reject the null only for the Indian market at a significance level of 1%. Table 2 summarizes the Kuiper’s basic test statistics $V$ \cite{Giles, 2007}, which is the sum of the maximum distance above and below the estimated reference distribution.

\footnote{The average of the Moody’s and S&P ratings, provided by Markit}
Fig. 1: Time aggregated rootograms for the US, European and Indian CDS market. The FSD means $d$ are 3.6 for the US, 3.66 for Europe and 3.18 for India.

Table 2: Kuiper test results.

<table>
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<tr>
<th></th>
<th>US</th>
<th>Europe</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>sample size N</td>
<td>76684486</td>
<td>67954791</td>
<td>9152070</td>
</tr>
<tr>
<td>Kuiper V</td>
<td>0.02462</td>
<td>0.02726</td>
<td>0.10343</td>
</tr>
</tbody>
</table>

Empirical FSD development through the crisis: As we are interested in the development of the empirical FSD distributions during the financial crisis Fig. 2 displays the FSD of US (top) and European (bottom) CDS spreads. Due to the huge deviations of the Indian CDS market from its estimated Benford-like distribution, this market is disregarded in further examinations.

The vertical lines in the graphs indicate key events in the financial crisis 2007. The first vertical line denotes the start of the crisis – July 17, 2007 – when Bear Stearns disclosed that two of its subprime hedge funds had lost nearly all of their value. The second line – March 16, 2008 – indicates the Fire Sale of Bear Stearns to JP Morgan and the last line indicates the collapse of Lehman Brothers (September 15, 2008). Fig. 2 shows that the FSD distribution for the US CDS market remains nearly constant. The lines in the graphs denote the empirical proportions of the single digits. From top to down, the first line stands for digit 1, i.e., at the beginning of our time series, 1 appeared as the first digit with 0.247 for European CDS spreads and with 0.257 for US CDS spreads. For digit 2 we observe at the first observation date 0.177 and 0.175 for the European and US markets, respectively. For digit 9 0.037, and 0.042 is observed. If the beginning of the subprime crisis was the default of two Bear Stearns Hedge Funds, we see from Fig. 2 that before the crisis the American as well the European market behave very similar. But from the beginning of the crisis, both markets develop completely different in terms of FSD distributions. While the US market remained more or less stable (the standard deviation for the 1 as a leading digit during the whole time period is only 0.02), we observe for the European market for digit 1 a standard deviation which is more than double, namely 0.05.

A well known difference between the US and European CDS market is their composition in terms of credit quality. The US CDS market is broader in the sense of credit quality, i.e., we observe more bad credit quality CDS entities. To eliminate such an effect we split our data into “investments” and “subinvestments”. The first group contains only entities with an average credit rating quality of at least A, while the second group contains all non-default entities below A, i.e., from BBB to CCC/C. The
results for these two groups are illustrated in Fig. 3.

As we can see in both groups – investment and subinvestment companies – the FSD distribution for US entities is more stable. The higher FSD fluctuation of the investment grade CDS market is caused by the fact that spreads are more concentrated at the lower end of the spread scale. I.e., we observe mainly spreads below 100 bpts. Therefore a change of the credit spreads is more likely to come along with a change in the FSD, than for spreads above e.g., 100 bpts. But as we can see from Figure 3 splitting the data into an investment and a subinvestment grade does not eliminate the regional differences in the FSD distributions.

V Conclusions and Discussions

In this letter we studied Benford-like distributions for the CDS market during the last financial crisis. First of all we illustrated the usefulness of such distributions to study data quality of the CDS market. We find out that for the Indian CDS market the observed CDS spreads do not follow the expected Benford-like distribution. Following the literature (Varian et al. 1972; George and Laura 2009) this could be a hint for “low” data quality. For the US and European market the data are in accordance
Fig. 3: FSD of the investment and subinvestment grade CDS spreads.

with the patterns of the corresponding Benford-like distributions. In studying the behaviour of the FSD distributions during the financial crisis 2007, we find huge fluctuations of the FSD for the European market, while the US market remains more or less constant. One possible reason could be that the European market was confronted with herding behaviour during the crisis (Devenow and Welch, 1996). Due to the increasing market uncertainty, market participants start to imitate and adopt the observed CDS prices. The missing of herding in the US market may be traced back to the Bankruptcy Code for US companies. Due to the Chapter 11 clause, firms “always” have the possibility of a strategic default. Jorion and Zhang (2007) discuss contagion effects and the US bankruptcy clauses, which sets the scene for further research that e.g., investigates contagion effects in the financial markets via FSD distributions.

References


