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Market conditions, default risk and credit spreads

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Discussion Paper
Series 2: Banking and Financial Studies
No 08/2008

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Internet http://www.bundesbank.de

ISBN 978-3–86558–406–9 (Printversion)
ISBN 978-3–86558–407–6 (Internetversion)

This paper was presented at the joint Deutsche Bundesbank / Basel Committee on Banking Supervision / Journal of Banking and Finance conference (December 2007) on "Interaction of Market and Credit Risk". The views expressed in the paper are those of the authors and not necessarily those of the Bundesbank, the Basel Committee on Banking Supervision or the Journal of Banking and Finance.

Conference on the Interaction of Market and Credit Risk

6–7 December 2007, Berlin

Thursday, 6 December

8:30 – 9:00 Registration (Harnack Haus)

9:00 – 9:15 **Welcome Address by Hans Reckers (Deutsche Bundesbank)**

Session 1 **Banking and Securitization**

Chair: Myron Kwast (Federal Reserve Board)

9:15 – 10:15 **Recent Financial Market Developments**
Keynote address by E. Gerald Corrigan (Goldman Sachs)

10:15 – 11:05 **Banking and Securitization**

Wenying Jiangli (Federal Deposit Insurance Corporation)

Matthew Pritsker (Federal Reserve Board)

Peter Raupach (Deutsche Bundesbank)

Discussant: Deniz O. Igan (International Monetary Fund)

11:05 – 11:30 **Refreshments**

Session 2 **Integrated Modelling of Market and Credit Risk I**
Chair: Klaus Duellmann (Deutsche Bundesbank)

11:30 – 12:10 **Regulatory Capital for Market and Credit Risk Interaction: Is Current Regulation Always Conservative?**

Thomas Breuer (Fachhochschule Vorarlberg)

Martin Jandačka (Fachhochschule Vorarlberg)

Klaus Rheinberger (Fachhochschule Vorarlberg)

Martin Summer (Oesterreichische Nationalbank)

Discussant: Simone Manganelli (European Central Bank)

12:10 – 13:00	**An Integrated Structural Model for Portfolio Market and Credit Risk**
	Paul H. Kupiec (Federal Deposit Insurance Corporation)
	Discussant: Dan Rosen (R^2 Financial Technologies Inc.)
13:00 – 14:30	**Lunch**
Session 3	**Integrated Modelling of Market and Credit Risk II** **Chair: Til Schuermann (Federal Reserve Bank of New York)**
14:30 – 15:20	**The Integrated Impact of Credit and Interest Rate Risk on Banks: An Economic Value and Capital Adequacy Perspective**
	Mathias Drehmann (European Central Bank)
	Steffen Sorensen (Bank of England)
	Marco Stringa (Bank of England)
	Discussant: Jose A. Lopez (Federal Reserve Bank of San Francisco)
15:20 – 16:10	**An Economic Capital Model Integrating Credit and Interest Rate Risk**
	Piergiorgio Alessandri (Bank of England)
	Mathias Drehmann (European Central Bank)
	Discussant: Andrea Sironi (Bocconi University)
16:10 – 16:40	**Refreshments**
16:40 – 18:00	**Panel discussion** **Moderator: Myron Kwast (Federal Reserve Board)** **Panelists: Pierre Cailleteau (Moody's),** **Christopher Finger (RiskMetrics),** **Andreas Gottschling (Deutsche Bank),** **David M. Rowe (SunGard)**
20:00	**Conference Dinner (with Gerhard Hofmann, Deutsche Bundesbank)**

Friday, 7 December

Session 4	**Risk Measurement and Markets** **Chair: Thilo Liebig (Deutsche Bundesbank)**
9:00 – 9:50	**A Value at Risk Analysis of Credit Default Swaps** Burkhard Raunig (Oesterreichische Nationalbank) Martin Scheicher (European Central Bank) Discussant: Alistair Milne (Cass Business School)
9:50 – 10:40	**The Pricing of Correlated Default Risk: Evidence From the Credit Derivatives Market** Nikola Tarashev (Bank for International Settlements) Haibin Zhu (Bank for International Settlements) Discussant: David Lando (Copenhagen Business School)
10:40 – 11:10	**Refreshments**
11:10 – 12:10	**Structural Models and the Linkage between Equity and Credit Markets** **Keynote Address by Hayne Leland (The University of California, Berkeley)**
Session 5A	**Securitization, Regulation and Systemic Risk** **Chair: Hayne Leland (The University of California, Berkeley)**
12:10 – 13:00	**Solvency Regulation and Credit Risk Transfer** Vittoria Cerasi (Milano-Bicocca University) Jean-Charles Rochet (Toulouse University) Discussant: Loriana Pelizzon (University of Venice)
13:00 – 14:30	**Lunch**
14:30 – 15:20	**Determinants of Banks' Engagement in Loan Securitization** Christina E. Bannier (Frankfurt School of Finance and Management) Dennis N. Hänsel (Goethe University Frankfurt) Discussant: Gabriel Jimenez (Bank of Spain)

15:20 – 16:10	**Systemic Bank Risk in Brazil: An Assessment of Correlated Market, Credit, Sovereign and Inter-Bank Risk in an Environment with Stochastic Volatilities and Correlations**
	Theodore M. Jr. Barnhill (The George Washington University)
	Marcos Rietti Souto (International Monetary Fund)
	Discussant: Mathias Drehmann (European Central Bank)
Session 5B	**Credit Dependencies and Market Risk** **Chair: Kostas Tsatsaronis (BIS)**
12:10 – 13:00	**Interaction of Market and Credit Risk: An Analysis of Inter-Risk Correlation and Risk Aggregation**
	Klaus Böcker (UniCredit Group)
	Martin Hillebrand (Sal. Oppenheim)
	Discussant: Rüdiger Frey (University of Leipzig)
13:00 – 14:30	**Lunch**
14:30 – 15:20	**Market Conditions, Default Risk and Credit Spread**
	Dragon Tang (Kennesaw State University)
	Hong Yan (University of South Carolina)
	Discussant: Til Schuermann (Federal Reserve Bank of New York)
15:20 – 16:10	**The Effect of Seniority and Security Covenants on Bond Price Reactions to Credit News**
	David D. Cho (State University of New York at Buffalo)
	Hwagyun Kim (Texas A&M University)
	Jungsoon Shin (State University of New York at Buffalo)
	Discussant: Joerg Rocholl (European School of Management and Technology in Berlin)
16:10 – 16:30	**Final Remarks by Philipp Hartmann (European Central Bank)**
16:30 – 17:00	**Refreshments**

Market Conditions, Default Risk and Credit Spreads*

Dragon Yongjun Tang† — *University of Hong Kong*

Hong Yan‡ — *University of South Carolina*

This version: January 22, 2008

ABSTRACT

This study empirically examines the impact of market conditions on credit spreads as motivated by recently developed structural credit risk models. Using credit default swap (CDS) spreads, we find that, in the time series, average credit spreads are decreasing in GDP growth rate, but increasing in GDP growth volatility. We document that credit spreads are lower when investor sentiment is high and when the systematic jump risk is low. In the cross section, we confirm that firm-level cash flow volatility raises credit spreads. More importantly, we demonstrate that the impact of market conditions on credit spreads is substantially affected by firm heterogeneity. During economic expansions, *ceteris paribus*, firms with high cash flow betas have lower credit spreads than those with low cash flow betas. This relation disappears during economic recessions, consistent with theoretical predictions.

JEL Classification: G12; G13; E43; E44

Keywords: Credit Risk; Credit Default Swaps; Credit Spreads; Market Conditions

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*We thank Lorenzo Garlappi, Shisheng Qu, Sheridan Titman, Efstathios Tompaidis, Sergey Tsyplakov and participants of the Conference on the Interaction of Market and Credit Risk, especially our discussant Til Schuermann, for useful comments. Part of the work was done while Tang was at the Kennesaw State University. We are responsible for remaining errors in the paper.

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Non-technical summary

In this paper, we empirically examine how macroeconomic conditions affect yield spreads on corporate bonds subject to default risk. We use spreads of credit default swap (CDS) contracts to proxy for credit spreads, and find that, over time, average credit spreads are lower during economic expansions, and they are higher during economic recessions. If economic growth is more volatile, that will also lead to higher credit spreads. We document that credit spreads are lower when investor sentiment is optimistic and when the risk a market-wide jump is low. Across firms, we confirm that firm-level cash flow volatility raises credit spreads. More important, we show that, during economic expansions, all else being equal, firms whose cash flows are highly correlated with the aggregate economic output have lower credit spreads than those with low cash flow correlations. This relation disappears during economic recessions, consistent with theoretical predictions.

Nichttechnische Zusammenfassung

In diesem Arbeitspapier untersuchen wir empirisch, wie die gesamtwirtschaftlichen Bedingungen die Renditeabstände von Unternehmensanleihen, die mit einem Ausfallrisiko behaftet sind, beeinflussen. Dabei verwenden wir Spreads von Kreditausfallswaps (Credit Default Swap, CDS) als Näherungswert für Kreditspreads und stellen fest, dass die durchschnittlichen Kreditspreads im Zeitverlauf bei wirtschaftlicher Expansion niedriger und bei wirtschaftlicher Rezession höher sind. Wenn das Wirtschaftswachstum volatiler ist, führt dies ebenfalls zu höheren Kreditspreads. Wir stellen fest, dass Kreditspreads bei positiver Anlegerstimmung und geringem Risiko eines marktweiten Sprungs niedriger ausfallen. Firmenübergreifend stellen wir fest, dass ein auf Unternehmensebene volatiler Cashflow zu einer Erhöhung der Kreditspreads führt. Was noch entscheidender ist, wir zeigen, dass in Zeiten wirtschaftlicher Expansion – bei ansonsten gleichen Bedingungen – Unternehmen, deren Cashflow stark mit dem gesamtwirtschaftlichen Wachstum korreliert, geringere Kreditspreads aufweisen als solche mit einer schwachen Cashflow-Korrelation. Im Einklang mit den theoretischen Voraussagen verschwindet dieser Zusammenhang in Zeiten wirtschaftlicher Rezession.

I. Introduction

Credit risk and market conditions are inherently linked. This link manifests itself in multiple channels. It has been documented that default probabilities and recovery rates vary through business cycles (see, e.g., Altman (1983), Acharya, Bharath, and Srinivasan (2007), Duffie, Saita and Wang (2007), and Pesaran, Schuermann, Treutler and Weiner (2006)). Market conditions may also impact how firm characteristics affect default probabilities and credit spreads, because economically sensitive firms should benefit in economic expansions and suffer in economic recessions. Traditional structural models based on the seminal Merton (1974) model, however, have generally not properly accounted for these inherent connections, which may partially cause the failure of these models to match the levels of the observed credits spreads ("the credit spread puzzle").[1]

Recently, a number of theoretical papers directly examine the impact of market risk on credit spreads. Tang and Yan (2006) investigate the dynamics of firm-level credit spreads by highlighting the role of a firm's cash flow beta that measures its exposure to macro-economic risk. They show that incorporating macro-economic influence on a firm's cash flow process helps improve the fit of default probabilities and credit spreads significantly, even in a model of a simple preference structure without a jump component in the cash flow process. Other papers introduce habit-formation or recursive preference structures in order to illustrate the connection between the equity risk premium puzzle and the credit spread puzzle (Bhamra, Kuehn and Strebulaev (2007) and Chen, Collin-Dufresne and Goldstein (2007)), or reconcile the observed high credit spreads with low corporate leverage ratios (Chen (2007)). Moreover, Chen (2007) and David (2007) consider the impact of inflation and allow for regime-switching in the growth rate of aggregate consumption or production to capture the uncertainty in the business cycle.[2] With these added features, these models can be calibrated to provide reasonable predictions of credit spreads consistent with empirical data.

A common feature of these models is that they adopt a consistent valuation framework by

[1] This problem with the traditional structural models has been documented in Jones, Mason and Rosenfeld (1984) and Huang and Huang (2003).

[2] The regime-switching mechanism, also considered in Hackbarth, Miao, and Morellec (2006) and Bhamra, Kuehn and Strebulaev (2007), introduces a jump component in the pricing kernel and through its correlation with the flow-level cash flow also prices the jump component at the firm level. This provides an economic backdrop to a new structural model proposed by Leland (2006), who shows that with the addition of a jump component and liquidity costs, traditional structural models can be made to match both default probabilities and credit spreads.

applying an endogenous stochastic discount factor (or pricing kernel) of the economy to evaluating corporate securities, including bonds, based on the observable cash-flow process. They produce a number of empirically testable predictions of the time-series and cross-sectional patterns of credit spreads. In this paper, we carry out an empirical examination of the impact of market conditions on credit spreads motivated by this recent theoretical development. We empirically assess the validity of these predictions using individual credit default swap (CDS) spreads which have been regarded as a better measure of credit risk than the ones obtained from corporate bond yields.

For the time-series pattern of credit spreads, we show that credit spreads are decreasing with the GDP growth rate and increasing with the growth volatility. This result is consistent with the earlier evidence that credit spreads widen during recessions and narrow during expansions at market level (e.g., Fama and French (1989)). We also document, for the first time, that credit spreads decrease with a sentiment measure based on the Conference Board Consumer Confidence Index. Because consumer/investor sentiment is usually negatively correlated with the market-wide risk aversion and uncertainty about future economic growth, this result is consistent with the notion that credit spreads depend on investors' risk attitude and their uncertainty about the prospect of the economy, as predicted by the models. Moreover, we document that credit spreads are positively related to the slope of the implied volatility over strike prices for S&P 500 index options, which is often used to proxy for the jump component in the underlying price process. This finding is consistent with the predicted impact of the regime-switching in economic growth which leads to a jump in the pricing kernel and precipitates jumps in the firm-level cash flow process.

A number of existing empirical studies use credit spreads of a bond index or average credit spreads within a particular rating class to characterize the dynamics of credit spreads (see, e.g., Huang and Huang (2003)). This approach may obscure the importance of firm heterogeneity and lead to underestimation of expected losses, as pointed out in Hanson, Pesaran and Schuermann (2007). Indeed, recent models provide some specific cross-sectional predictions. We find that, across firms, credit spreads decrease with the firm-specific growth rate of cash flows and increase with the cash-flow volatility, as predicted. More interestingly, we detect an important and time-varying role of the cash-flow beta, which measures the covariation of the firm-level cash flow with the aggregate output. In particular, the evidence suggests that during economic expansions, a high cash-flow beta helps reduce credit spreads, while during economic recessions, a high cash-flow beta may increase credit spreads. This pattern, consistent with the model prediction in Tang and Yan (2006), highlights the effect of the interaction of market risk and credit risk on the dynamics of credit spreads.

Our study provides a fresh perspective on the importance of macroeconomic conditions in assessing credit risk and credit spread dynamics. Jarrow and Turnbull (2000) suggest that incorporating macroeconomic variables may improve a reduced-form model of credit spreads. Collin-Dufresne, Goldstein, and Martin (2001) argue for "the need for further work on the interaction between market risk and credit risk — that is, general equilibrium models embedding default risk." Recent theoretical papers discussed before represent initial steps in meeting this challenge. Some earlier empirical studies have also touched upon several aspects connecting macro variables (or systematic factors) with credit spreads and/or default probabilities, such as Fama and French (1989), Bakshi, Madan and Zhang (2006), Pesaran, Schuermann, Treutler and Weiner (2006) and Duffie, Saita and Wang (2007). However, the structural framework underlying this study allows us to systematically investigate the impact of market conditions and the interaction of market risk and firm characteristics on firm-level credit spreads.

Valuation of risky debt is central to corporate financing choices and credit investors' portfolio management. The findings in this study should improve our understanding of the determinants of credit spreads, which is important for banking regulators as well because Basel Committee on Banking Supervision (BCBS) of the Bank for International Settlements (BIS) recently allowed banks to evaluate their own credit risk and capital requirement through internal credit scoring. This new rule, known as Basel II, puts much faith upon banks' ability to accurately model their credit risk exposure. Research work trying to uncover the interaction of market risk and credit risk should help us better assess the portfolio risk of credit liabilities and implement more appropriate risk management measures.

The rest of this paper is organized as follows. Section II describes basic features of the recently developed models that incorporate market conditions into defaultable bond pricing and motivates our empirical investigation. Section III introduces the CDS data used for the empirical analysis. Sections IV and V present results of the time-series and cross-sectional patterns of credit spreads based on the model implications, respectively. Section VI concludes.

II. Market Conditions and Firm-Level Credit Risk: Theory and Implications

The recent literature has seen a number of theoretical papers attempting to link credit spread dynamics to macroeconomic conditions and/or the equity risk premium. These papers include Tang and Yan (2006), Hackbarth, Miao, and Morellec (2006), Bhamra, Kuehn and Strebulaev (2007), Chen (2007), Chen, Collin-Dufresne and Goldstein (2007), and David (2007). In this section, we discuss this line of structural modeling and explore their empirical implications.

A. The Market Risk

The market risk is captured through the dynamics of a stochastic discount factor (SDF), also known as the pricing kernel, $M(t)$, in the following form:

$$\frac{dM(t)}{M(t)} = -r(s_t)dt - \sigma_M(s_t)dZ(t), \tag{1}$$

where $r(s_t)$ is the risk-free rate with s_t representing relevant state variables, $\sigma_M(s_t)$ is the price of risk due to systematic shocks of $Z(t)$, represented by a standard Brownian motion. As shown in Tang and Yan (2006), a particular form of this SDF, in which the risk-free rate is linear in the growth rate of the aggregate consumption, can be supported in a general equilibrium of an economy of representative agents with a power utility over consumption. David (2007) also considers the dynamics of the inflation rate and assumes that the real risk-free rate is linear in the inflation rate.

Given the difficulty power utility has with accounting for the magnitude of the equity risk premium ("the equity premium puzzle"), Bhamra, Kuehn and Strebulaev (2007) and Chen (2007) derive the dynamics of the SDF assuming a representative-agent economy with stochastic differential utility of Duffie and Epstein (1992), which is the continuous-time version of the recursive preferences (Kreps and Porteus (1978) and Epstein and Zin (1989)). Alternatively, Chen, Collin-Dufresne and Goldstein (2007) adopt the habit-formation utility set-up in Campbell and Cochrane (1999). Both Bhamra, Kuehn and Strebulaev (2007) and Chen, Collin-Dufresne and Goldstein (2007) explore the potentially inherent connection between the equity premium puzzle and the "credit spread puzzle", that is, credit spreads are too high to be accounted for by existing structural models (e.g., Huang and Huang (2003)).

Moreover, Bhamra, Kuehn and Strebulaev (2007), Chen (2007) and David (2007) allow for a regime-switching process in the growth rate of the aggregate consumption or production. As shown in Chen (2007), this switching between growth regimes introduces a jump component augmented to the dynamics of the pricing kernel in (1). This dynamics of the pricing kernel summarizes the influence of the conditional market risk that is tied to macroeconomic conditions and can be used to price corporate securities written on various types of cash flows.

B. Firm-Level Cash Flows

A firm's cash-flow process is generally specified as

$$\frac{dK(t)}{K(t)} = \theta(s_t)dt + \sigma_K(s_t)\rho(s_t)dZ(t) + \sigma_K(s_t)\sqrt{1-\rho^2(s_t)}dZ_F(t), \tag{2}$$

where $\theta(s_t)$ is the drift for the cash-flow process, $\sigma_K(s_t)$ is its volatility, $Z_F(t)$ is a standard Brownian motion to capture firm specific shocks that are independent of systematic shocks, $Z(t)$, and ρ is the correlation between the firm-level cash flow process and the aggregate output process. This specification of a firm's cash flows as the primary process is used in Tang and Yan (2006), Bhamra, Kuehn and Strebulaev (2007), and Chen (2007). Tang and Yan (2006) model the drift term as

$$\theta(s_t) = \beta\mu(t) + \xi(t), \tag{3}$$

where $\xi(t)$ is the firm-specific growth rate which is independent of the growth rate of the aggregate output, $\mu(t)$. The sensitivity of the firm-level growth rate to the aggregate growth rate may be described by

$$\beta = \mathrm{Cov}\left(\frac{dK(t)}{K(t)}, \frac{dQ(t)}{Q(t)}\right) \Big/ \mathrm{Var}\left(\frac{dQ(t)}{Q(t)}\right) = \rho\frac{\sigma_K}{\sigma_Q}, \tag{4}$$

where $Q(t)$ represents the aggregate output and σ_Q its growth volatility. Thus, β may be thought of as the cash flow beta in Campbell and Vuolteenaho (2004).

This specification of firm-level cash flows does not explicitly investigate a firm's investment opportunities and capital structure decisions. Rather, the purpose in this set of papers is to evaluate securities written on these cash flows using the pricing kernel developed earlier. While considerations of corporate investment and financing policies will undoubtedly enrich our understanding of the valuation of corporate securities, they will introduce more complexity before we have a better understanding of the pricing effect of macroeconomic conditions. In general, this simple approach applies the contingent claim approach to value a bond that uses the cash flow $K(t)$ as collateral.

Most structural credit risk models price bonds based on an exogenously specified asset value process, which is unobservable and may not be internally consistent with a pricing kernel that prices securities in a unified framework. In those models, default occurs when the firm value falls below some threshold. In contrast, the focus here is on a firm's cash flow as a primary observable process, following Goldstein, Ju, and Leland (2001) who model the firm-level cash flow directly in determining the optimal dynamic capital structure choice. In Tang and Yan (2006), a firm defaults when it does not have enough cash to pay its dues.[3] Chen (2007) and Bhamra, Kuehn and Strebulaev (2007), on the other hand, study the optimal default boundary, determined by a critical cash-flow level, by allowing for equity issuance and imposing the smooth-pasting conditions for the equity value at the boundary.

C. Bond Valuation

Bond valuation and the calculation of credit spreads may be carried out using the specified stochastic discount factor to price the coupon stream and the final payoff of a bond. Following Tang and Yan (2006), we consider a risky debt that has a face value F, a coupon payment rate c, and maturity T.[4] During each period, Δt, the firm promises to pay bondholders a fixed coupon, $c\Delta t$, before the bond matures. The firm defaults when its cash flow is not enough to cover the coupon payment, $K < c$. In that event, either reorganization or liquidation is imposed and bondholders recover a fraction $w(\cdot)$ of the face value F. The payoff stream of

[3] Uhrig-Hombug (2005) explicitly models cash flow shortage as an endogenous bankruptcy reason in the presence of equity-issuance costs. Kim, Ramaswamy, and Sundaresan (1993) also argue that firm defaults when its cash flow is not sufficient for its coupon payments.

[4] Chen (2007) and Bhamra, Kuehn and Strebulaev (2007) consider a defaultable bond with a promised perpetual coupon stream.

this defaultable bond is then

$$g(t) = c \cdot \mathbf{1}(t \leq T) \cdot \mathbf{1}(t < \tau) + F \cdot \delta(t - T) \cdot \mathbf{1}(t < \tau) + w(\cdot) F \cdot \delta(t - \tau) \cdot \mathbf{1}(t \leq T), \qquad (5)$$

where $\tau = \inf\{t : K(t) < c\}$ is the first passage time representing the time of default, and $\delta(t - \tau)$ is the Kronecker delta.

The recovery rate, $w(\mu_t)$, depends on the current growth rate of the economy, as Altman, Brady, Resti, and Sironi (2005) and Acharya, Bharath, and Srinivasan (2007) show that macroeconomic and industry conditions at the time of default are important and robust determinants of the recovery rate. This relation can be captured in a parsimonious way by assuming

$$w(\mu_t) = a + b\mu_t, \qquad (6)$$

where $b \geq 0$ and $w \in [0, 1]$.

The value of the risky debt (DV) is then given by the difference of the value of a default risk-free bond with an identical payment structure (FV) and the expected loss of the risky bond (EL). The expected loss given default (LGD) consists of three components: the present value of the sum of all remaining coupon payments, the present value of the loss on the principal, and the present value of the reinvestment on the recovered principal, as shown in Tang and Yan (2006). The yield to maturity of this risky bond, Y, is then implicitly defined by

$$DV = \frac{c}{Y} + \left(F - \frac{c}{Y}\right) e^{-YT}. \qquad (7)$$

Similarly, the yield to maturity of a risk-free bond with the same payment structure, R, is given by

$$FV = \frac{c}{R} + \left(F - \frac{c}{R}\right) e^{-RT}. \qquad (8)$$

Following the extant literature, the credit yield spread is defined as $Y - R$.

D. Empirical Implications

The models we discussed before are calibrated to produce some interesting results with their own specific objectives. Chen, Collin-Dufresne and Goldstein (2007) show that a pricing kernel of the habit-formation variety designed to account for the equity risk premium may be used to produce credit spreads for an average firm comparable to the historical data, if one allows for a counter-cyclical default boundary for the firm value. Bhamra, Kuehn and Strebulaev (2007) argue that in their model of representative agents with a recursive utility function and business cycles captured by switching regimes, optimal capital structure choices lead to a default boundary that is counter-cyclical in cash-flow terms, but procyclical in terms of asset values. The inter-temporal macroeconomic risk drives both the equity risk premium and the credit spread on bonds. Chen (2007) demonstrates that this framework can also account for the phenomenon of high credit spreads and low leverage ratios that has failed the existing structural models. David (2007) also considers the effect of learning uncertainty about the state of the economy.

Tang and Yan (2006) use a much simpler modeling framework than other papers, as their aim is to investigate the joint effect of macroeconomic conditions and firm characteristics on the dynamics of credit spreads. In particular, they examine how the cross-sectional properties of credit spreads change with economic conditions. They calibrate their model to historical default frequencies and leverage ratios, similar to the approach in Huang and Huang (2003) and Leland (2004). Even though their simple framework does not fully capture the dynamic process of the market risk premium, it demonstrates the crucial importance of incorporating macro-economic dynamics for credit spreads. Their model is able to generate higher yield spreads for high-grade bonds and lower yield spreads for junk bonds than other earlier models which tend to underestimate the spreads for highly rated bonds and over-predict the spreads for very risky bonds (see, e.g., Eom, Helwege, and Huang (2004)).

Analysis in these papers yields results that manifest the significant impact of macroeconomic conditions on credit spreads, with major predictions consistent across all models. Below, we discuss their empirical implications as exemplified in Tang and Yan (2006).

First, credit spreads are counter-cyclical, widening during recessions and narrowing during economic expansions, consistent with the empirical evidence, such as in Fama and French (1989). This result is also related to the observed negative correlation between interest rate and credit spreads, as in Longstaff and Schwartz (1995), due to an inherently close relation between the economy growth rate and the risk-free rate. The intuition for this result is as follows. The growth rate of a firm's cash flow process with a positive cash-flow beta is positively related to the economic growth rate. All else being equal, an increase in the economic growth rate, such as the GDP growth rate, will increase the firm-level growth rate and hence decrease the default probability and the credit spread.

Second, theoretical analysis indicates that credit spreads increase with the volatility of the economic growth rate. A firm is more likely to experience cash flow shortfalls in a more volatile economic environment, and hence more likely to default. Therefore, this is the effect of the intertemporal economic risk, as the volatility of the economic growth rate tends to be higher in recessions than expansions. Hence, this implication distinguishes the risk effect from the growth effect discussed above.

Third, credit spreads also widen when investors are more risk averse. It is believed that investors become more risk averse during economic downturns, and this effect has been linked to the "flight to quality" phenomenon. Although the papers we discussed do not explicitly model the endogenous change of investors' preferences, comparative static analysis provides a gauge of the sensitivity of credit spreads to changes in preferences, which in turn affects the market price of risk. One possible proxy for investors' preferences is the measure of their sentiments. We will discuss further the use of sentiment measures to proxy for investors' attitude towards risk in our empirical examination.

The firm-level analysis of credit spreads also yields cross-sectional implications for credit spread dynamics and for the effect of the interaction between macroeconomic conditions and industry or firm-level characteristics. First, it indicates that credit spreads should decrease with the current firm-specific growth rate and increase with the volatility of cash flows. Second, the correlation between the firm-level cash flow and the aggregate output, as expressed in (5), introduces a joint effect of market conditions and firm characteristics. One implication is that credit spreads may increase with the cash flow beta during the economic downturn while decrease with the cash flow beta during the economic expansion. This highlights the impact of the interaction of market risk and credit risk on credit spreads due to firm heterogeneity.

In the remainder of this paper, we examination these implications with the credit default swap (CDS) data, which we describe in the next section.

III. Data and Sample Description

Several data issues make empirical analysis of credit risk difficult. Because the corporate bond market is relatively thin and many bonds do not trade on a daily basis, dealers fill in non-traded bonds with matrix prices (referencing a matrix of similar bonds). Sarig and Warga (1989) show that matrix prices are problematic for making inferences from the data. Corporate bond yields are also found to contain substantial liquidity and tax premia due to the illiquidty of the corporate bond market and different tax treatments between corporate bonds and Treasury bonds.[5] Many corporate bonds also have embedded options, further complicating the measurement of credit spreads based on bond yields. To make the matter worse, there is an issue of an adequate reference for the risk-free rate.[6]

The rapidly growing credit derivatives market provides a resolution for the data problem.[7] Without the problems of a reference risk-free rate and optionality and with improved liquidity in the CDS market, credit default swap (CDS) spreads have been used to proxy for credit spreads. Duffie (1999) shows that under certain conditions, CDS spreads indeed equal credit spreads. Tang and Yan (2007) and Ericsson, Jocobs, and Oviedo (2007), among others, show that a large portion of CDS spreads can be directly attributed to credit risk.

Our CDS data are from two major CDS brokers: CreditTrade and GFI. Both data sources were previously used in the literature (e.g., GFI data in Hull, Predescu, and White (2004), and CreditTrade data in Blanco, Brennan, and Marshall (2005)). It is a rare instance to combine these two data sources. Our CreditTrade dataset spans from June 1997 to March 2006, and our GFI dataset covers the period between January 2002 and November 2006.[8] The combined database has information on intraday quotes and trades, including transaction time, reference entity (bond issuer), seniority of the reference issue, restructuring code, maturity, notional amount and currency denomination of a CDS contract. In this study, we use CDS prices for non-sovereign U.S. corporate bond issuers denominated in U.S. dollars, with the reference issue ranked senior and CDS maturity between 4.5 and 5.5 years. Monthly data are obtained by averaging transactions within the month. In our dataset, there are 26548

[5]See, e.g., Longstaff, Mithal, and Neis (2005), Chen, Lesmond, and Wei (2007), and Covitz and Downing (2007) for a liquidity component, and Elton, Gruber, Agrawal, and Mann (2001) for the tax issue.

[6]Krishnamurthy and Vissing-Jorgensen (2007) argue that Treasury securities play a significant role of providing liquidity services that distorts their function of providing benchmark risk-free rates. Longstaff (2004) and Houweling and Vorst (2005) discuss different candidate risk-free yield curves.

[7]The International Swaps and Derivatives Association (ISDA) 2006 Year-End Market Survey reports that the notional amount of CDS on single-names, baskets and portfolios of credits and index trades reached $34.4 trillion by December 31, 2006. The figures from the Bank of International Settlements (BIS) show the notional amount of $28.8 trillion for credit derivatives by the end of 2006, of which $18.9 trillion is for single-name CDS contracts.

[8]According to *Risk* magazine's inter-dealer rankings, CreditTrade was the number one CDS broker before 2004, and GFI has been the top credit derivatives broker in the last several years.

issuer-month CDS spread observations with an average CDS spread of 110.5 basis points.

Average CDS spreads are plotted in Figure 1. There is a significant time-series variation in average CDS spreads. CDS spreads peaked in the second half of 2002 due to the turbulence in the credit market. They subsequently declined, possibly due to (1) improved macroeconomic conditions which tend to reduce the aggregate credit risk; (2) the increasing dominance of high quality issuers in the market; or (3) increased competition in the market that has improved the efficiency in the prices of CDS contracts.

Table I provides the year-by-year summary statistics for the sample. Two observations from the summary table are noteworthy. First, the average spread for AAA bonds is about 35 basis points, which is still much higher than the predicted value by most of the traditional structural models. Second, CDS spreads for AAA bonds are not always smaller than CDS spreads for AA bonds. Both observations indicate that CDS spreads may not be fully accounted for by credit risk alone. Other factors such as liquidity may also contribute to the prices (e.g., Tang and Yan (2007)). An alternative explanation is that CDS spreads may react to news more promptly than credit ratings. For AAA bonds, the only possible rating change is downgrade. Therefore, the market CDS price could have incorporated information before rating agencies adjust the ratings.

While the focus of our empirical analysis is on credit spreads measured by CDS spreads, we also conduct some analysis on default probabilities. Default probabilities and credit spreads are positively correlated. Consistent findings using default probabilities and credit spreads will strengthen the validity of our empirical results. We use Moody's KMV's Expected Default Frequency (EDF) as a measure of default probability. This measure is widely used in the industry, in addition to credit ratings from ratings agencies, such as Moody's and S&P. Its advantage comes from the frequent updating of credit situations because the indicator is based on the stock price of a reference firm. The time series of five-year market average EDF is plotted in Figure 1. It can be seen that the correlation between EDFs and CDS spreads are pretty high, although there are periods when these two measures diverge (such as in 2001 and 2004).

Our sample selection is therefore limited to the firms with outstanding CDS contracts during the time period between June 1997 and November 2006. There are additional requirements pertaining to the number of observations needed in respective tests. These requirements will be discussed in the following two sections as they become relevant, together with descriptions of additional data of macroeconomic variables and firm-level characteristics.

IV. Time-Series Results: Macroeconomic Conditions and Credit Spreads

Extant literature has shown that interest rates and corporate bond yield spreads fluctuate over business cycles, as aggregate and firm-level outputs critically depend on the state of the economy. For instance, Altman (1983) documents that, among other economic variables, real economic growth can predict aggregate business failures. Fama and French (1989) find that credit spreads widen when economic conditions are weak. Duffie, Saita and Wang (2007) show that macroeconomic variables can help explain a significant portion of default rates or yield spread changes. Bakshi, Madan and Zhang (2006) and Elton, Gruber, Agrawal and Mann (2001) find that a substantial portion of corporate bond credit spreads may be explained by factors commonly used to model risk premiums for common stocks. Altman, Brady, Resti, and Sironi (2002) demonstrate the impact of business cycles on the correlation between default and recovery. Moreover, industrial practice has already incorporated the effect of macroeconomic variables on default probabilities (e.g., McKinsey's CreditPortfolioView and Algorithmic's Mark to Future), despite the lack of theoretical support.

In this section, we empirically test several predictions from the structural credit risk models conditioned on macroeconomic variables, such as in Tang and Yan (2006) and others reviewed earlier. Our empirical examination employs credit default swaps (CDS) data for credit spreads and Moody's KMV EDF data for the default probability measure. Hence, compared to existing empirical studies, our examination has two distinct advantages: high quality firm-level data of credit spreads and default risk, and theory-motivated hypotheses.

A. Hypothesis and Variable Construction

The first implication of the theory, as articulated in Tang and Yan (2006), David (2007), Chen (2007), and other models, is that *default probability and credit spreads decrease with the economic growth rate.* This is intuitive as a high economic growth rate leads to a high growth rate at the firm-level, which reduces the likelihood of default and in turn the credit spread. The most intuitive proxy for economic growth is the real GDP growth rate. We obtain the real GDP data from the Federal Reserve Economic Database (FRED).[9] GDP numbers are only available at quarterly frequency. We interpolate quarterly GDP numbers to obtain monthly growth rate, although this interpolation does not materially affect our results. For robustness check, we also report the results using the monthly industrial production growth rate, obtained from FRED, as a proxy for economic growth.

Credit spreads are associated with the risk premium for holding defaultable bonds. The higher the volatility of economic growth, the higher risk premium for the entire economy. In a more volatile economic environment, firms are more likely to encounter difficulty in meeting their payment obligations. Therefore, the second implication is that *default probability and credit spreads increase with the volatility of the economic growth rate.* Estimating economic growth volatility at a higher frequency, however, is a daunting task because economic growth rates are usually reported at a low frequency. To mitigate the problem with the lack of high-frequency macroeconomic data for a contemporaneous estimate of volatility, we follow McConnell and Perez Quiros (2000) and use the unexpected GDP growth rate to proxy for growth volatility by estimating the following AR(1) model:

$$\Delta\mu_t = \omega + \phi\Delta\mu_{t-1} + \epsilon_t, \tag{9}$$

where $\Delta\mu_t$ is the monthly growth rate, ϕ measures the persistence of growth rate. McConnell and Perez Quiros (2000) show that $\sqrt{\pi/2}|\epsilon_t|$ is an unbiased estimate of the true volatility. Hence, we use $|\epsilon_t|$ to proxy for growth volatility.[10] We also apply this procedure to the growth rate of industrial production.

When investors are more risk averse, they require a higher risk premium for holding risky assets. Hence changing risk aversion will change the market risk premium and affect credit spreads as well. Unfortunately, we do not directly observe the level of investor risk aversion, and whether it is varying with time is also subject to debate. A typical approach to estimate risk aversion is to extract risk premium using option prices (See Jackwerth (2000) and Bliss and Panigirtzoglou (2004)). This approach generates one risk aversion estimate for each option and then a certain type of aggregation is needed to obtain an estimate for the market risk

[9] http://research.stlouisfed.org/fred2/

[10] We have also used monthly average implied volatility of the at-the-money S&P 500 index options from OptionMetrics to proxy for the volatility of economic growth rate and obtain similar results. The implied volatility is forward-looking as it contains investors' expectation about future market volatility.

aversion. Instead of this elaborate process of estimating the market risk aversion, which is inherently model-dependent, we opt to using a simpler proxy using a measure of investor sentiment.[11] Therefore, we will investigate whether *credit spreads decrease with investor sentiment.* Among several available measures of investor sentiment, only Conference Board Consumer Confidence Index and University of Michigan Consumer Sentiment are updated monthly.[12] Qiu and Welch (2004) show that survey-based sentiment measures are superior to other constructed measures.[13] We use the monthly Conference Board Consumer Confidence Index as our sentiment measure. Similar results are obtained using the Michigan Consumer Confidence Index.

Leland (2004, 2006) argues that a jump component in a firm's asset process is critical to matching observed default probabilities. A jump component is also incorporated in Huang and Huang (2003) and Cremers, Driessen and Maenhout (2007). Theoretically, the systematic jump component is captured through regime switching in Hackbarth, Miao, and Morellec (2006), Bhamra, Kuehn and Strebulaev (2007), Chen (2007), and David (2007). The implication is that *default probability and credit spreads increase with the jump risk.* Empirically, we measure the jump risk using the slope of the implied volatility over strike prices for S & P 500 index options, following Cremers, Driessen and Maenhout (2007).

Putting together these implications, the hypothesis we test regarding the effect of the market risk on credit spreads can be summarized as the following:

HYPOTHESIS 1 *Default probability and credit spreads are lower if the GDP growth rate is higher, if the growth volatility is lower, if the sentiment is stronger, and if the implied volatility of the S & P 500 index options is flatter.*

Figure 2 plots the time series of those macroeconomic series, along with the market average CDS spreads. It is rather clear that credit spreads are negatively correlated with investor

[11]We recognize the important distinction between investor sentiment and risk aversion. Sentiment reflects investors' belief about future market movement. Risk aversion measures investors' taste for risky assets over risk-free assets. Nevertheless, these two measures are highly correlated. When investor sentiment is low, investors may save more in preparation for upcoming bad times, and hence raise the risk premium. Similar behavior may be observed in a market with highly risk averse investors.

[12]Other sentiment proxies include Barron's weekly investor confidence index, Investor Intelligence Index, State Street Investor Confidence Index, Hulbert Nasdaq Newsletter Sentiment Index, etc.

[13]Baker and Wurgler (2006) construct a sentiment measure but it is only available at an annual basis. Kaniel, Saar, and Titman (2005) construct an individual investor sentiment measure (on a daily basis), but their data are not readily available.

sentiment but positively correlated with growth volatility. Table II provides the descriptive statistics of those macroeconomic series. It shows that correlations among those series are rather low, thus mitigating the concern of multi-collinearity in multivariate regressions.

B. Methodology

In order to evaluate the joint effects of those macroeconomic variables, we conduct a regression analysis. We use three approaches to ensure robust results. Because in this analysis we focus on the relation between macroeconomic conditions and credit spreads in the time series, we first regress market average CDS spreads on those four economic variables (*the market average approach*). This approach assumes that firm characteristics affecting credit spreads are not correlated with macroeconomic conditions and the level of market average CDS spreads is solely determined by macroeconomic conditions.

Admittedly, this assumption is rather strong. For instance, Korajczyk and Levy (2003) show that firm leverage is strongly influenced by macroeconomic conditions. In order to relax this assumption, in *the firm-by-firm approach*, we regress CDS spreads on macroeconomic variables for each firm. We keep firms with at least 16 monthly observations. We have 176 such time series regressions. We then calculate the cross-sectional means and standard errors of those coefficient estimates. The standard errors are adjusted by the number of firms in the cross-section. This approach, used by Collin-Dufresne, Goldstein, and Martin (2001), implicitly assumes that firms are independent in order to make justification to the standard errors.

In addition, we also adopt a two-stage approach, following Titman, Tompaidis, and Tsyplakov (2005), which we dub as *the residuals approach*. In the first stage, we regress CDS spreads on cross-sectional fundamental determinants of credit spreads with issuer fixed effects and monthly dummies. The coefficients for the monthly dummies can be attributed to any time-series effects unexplained by cross-sectional variables. In the second stage, we regress the coefficient estimates for monthly dummies from the cross-sectional regressions on macroeconomic variables.

C. Empirical Analysis

We regress CDS spreads on the four macroeconomic variables and report the results in Table III. Overall, macroeconomic conditions have a significant impact on credit spreads. Hypothesis 1 is strongly supported in all three approaches, with some variations in the parameter estimates and their statistical significance across specifications.

During our sample period, GDP growth rate is a significant determinant of average credit spreads. Referring to Panel A of Table III, on average, a one-percent increase in GDP growth lowers credit spreads by 6-7 basis points. If we assume that the difference in GDP growth rates between expansion and recession is 7%, then the credit spread difference across business cycles is in the range of 42-49 basis points. We also find that growth volatility is positively related to credit spreads. A one-percent increase in growth volatility raises credit spreads by 2-7 basis points. In our sample, growth volatility can differ by about 3.5% across time, generating a change in credit spreads around 7-25 basis points.[14]

Investor sentiment is significantly negatively associated with credit spreads. It is actually the strongest explanatory variable among these four macroeconomic variables in all three specifications. A one-standard deviation move in investor sentiment is associated with CDS spread change of about 25 basis points. In comparison, one standard deviation move in GDP growth affects CDS spreads by about 15 basis points. Therefore, the effect of investor sentiment on credit spreads is economically significant.

It has long been recognized among practitioners that investor sentiment affects bond yields. In fact, *Barron's* constructs its investor confidence index by dividing the average yield on high-grade bonds by the average yield on intermediate-grade bonds. The discrepancy between the yields is indicative of investor confidence. A rising ratio indicates investors are demanding a lower premium in yield for increased risk and as such are showing confidence in the economy. Our results and the associated economic foundation provide a support for such a link between credit spreads and investor confidence measures.

The effect of the jump risk on credit spreads is positive but the significance level varies across specifications. In the *Average* and *Residuals* time-series regressions, a one-standard-

[14] We find that implied volatility of the S & P index options has a much stronger effect on credit spreads. However, because the implied volatility may reflect other influences in addition to growth volatility, we report here only the results on the growth volatility.

deviation change in the jump risk affects average CDS spreads by about 4.6 basis points, at 15% significance level. However, firm-level regressions show a highly significant jump risk effect, both statistically and economically. This result is actually sensible, because both *Average* and *Residuals* regressions are equivalent to examining the time-series properties of credit spreads of portfolios, which ignore the heterogeneity across firms, as pointed out in Hanson, Pesaran and Schuermann (2007). The firm-level regressions take into account the firm heterogeneity and demonstrate the importance of the *systematic* jump risk at the individual firm level.[15] This is consistent with the argument of Leland (2006) that a jump component is crucial for fitting credit spreads with structural models.

The differences in R^2s across the three specifications are worth noting. First, about 57% of the variation in market average CDS spreads is accounted for by the four macroeconomic variables, the remainder is possibly due to omitted macroeconomic variables and "frailty" as discussed by Duffie, Eckner, Horel, and Saita (2006). The R^2 in the *Residuals* regression, which like the market average regression involves the times series regression of a cross-sectionally aggregated variable (time dummy), is consistent with this conjecture. In untabulated results, we find that the time-series regression R^2 improves to 71% after we include other macroeconomic variables such as risk-free rate, term spread, AAA-BAA spread, etc. Secondly, the average R^2 of the firm-by-firm regressions is 32%, 25% below the R^2 of the market average regression, indicating that omitted firm heterogeneity could play a significant role in firm-level analysis, consistent with the argument in Hanson, Pesaran and Schuermann (2007).

As mentioned before, our monthly time series of GDP growth rates is obtained through the interpolation of the quarterly data. We do, however, arrive at qualitatively similar results using quarterly data directly, albeit with fewer observations of other variables and reduced power. For further robustness check, we use the monthly observable industrial production (IP) instead of GDP to re-do the analysis and report the results in Panel B of Table III. The coefficient on the IP growth rate is significantly negative, consistent with that for the GDP growth rate. However, IP growth volatility is insignificant with an opposite sign compared to that for GDP growth volatility. Overall, the effect of IP growth on credit spreads appears to be weaker than that of GDP growth, and the R^2s are generally lower in the IP analysis than the GDP analysis. Furthermore, in an untabulated analysis, we find that the IP growth rate becomes insignificant after we include the GDP growth rate. Even though Das, Duffie,

[15] We also find that the distributions of firm-level regression coefficients distribution are uni-modal, suggesting that credit risk induced by firm heterogeneity is diversifiable in portfolios.

Kapadia, and Saita (2007) analyze the impact of IP growth shocks on default probabilities, our results indicate that GDP growth as a measure of the growth rate of aggregate economic output, in which industrial production has a shrinking portion, may be a better state variable.

To further investigate the effect of macroeconomic conditions on default risk, we use Moody's KMV's EDF as a measure of default probability and regress EDFs on the macroeconomic variables. This exercise serves two important purposes. First, default probability is a purer measure of the risk of default, while credit spreads contain additional effects of recovery and liquidity. Secondly, the EDF measure has both one-year horizon and five-year horizon, and thus allows us to differentiate the impact of market conditions on the term structure of credit risk. This is not feasible at this time with the data of CDS spreads as prevailing CDS contracts in our dataset are of a five-year term. The time period of our analysis using the EDF measure is from January 1996 to October 2004, which overlaps a great deal with the time period in our analysis with CDS spreads.

The results of this analysis are reported in Table IV. Panel A presents the results for 5-year EDFs and Panel B for 1-year EDFs. The overall results are consistent with the findings for credit spreads discussed above. We make two interesting observations. First, the statistical significance of the macro-economic effect appears much stronger in firm-level regressions than in regressions on average or residual EDFs, a phenomenon that is more pronounced than in Table III with CDS spreads. This highlights more strongly the importance of firm heterogeneity in assessing credit risk. Secondly, the systematic jump risk is more significant for the short-term default risk than for the long-term default risk. This is consistent with the findings in Leland (2006) and Duffie and Lando (2001) that a jump component is necessary for matching short-term default probabilities and credit spreads.

In summary, our empirical analysis shows that economic growth rate, growth volatility, investor sentiment, and jump risk have significant economic impacts on default probabilities and credit spreads. In particular, our results indicate that a one-standard-deviation shift in investor sentiment could move average credit spreads by as much as 25 basis points, *ceteris paribus*, compared to a 15 basis point move attributable to a similar shift in the GDP growth rate. Macro-economic risks as proxied by the volatility of GDP growth and a jump measure appear to have effects of a similar, albeit somewhat smaller, magnitude, suggesting an important role of firm heterogeneity that leads to cross-sectional variations in the impact of market conditions on firm-level credit risk. This is what we turn to in the next section.

V. Cross-Sectional Results: Firm Characteristics and Credit Spreads

The time-series pattern of credit spreads reveals the importance of firm heterogeneity. There have been many studies that document the impact of firm-level characteristics, such as leverage ratio, profitability, and stock volatility, on default probability and, in turn, on credit spreads. Theoretically, Tang and Yan (2006) make additional predictions on the effect of firm's cash-flow characteristics on credit spreads and on the interaction of market conditions and credit risk. In this section, we empirically test these predictions.

A. Hypotheses and Cash Flow Variable Construction

The effect of cash flow variables on credit spreads has not been extensively examined in the empirical credit risk literature. We are aware of only a couple of studies, such as Minton and Schrand (1999) and Molina (2005), that analyze the effect of cash flow volatility on corporate bond yield spreads. When a firm's cash flow is more volatile, it is more likely that it will have a cash shortfall, which may lead to financial distress and even default. Therefore, we should expect that *credit spreads increase with cash flow volatility.* Indeed, Minton and Schrand (1999) and Molina (2005) have presented evidence in support of this prediction. We re-evaluate this prediction, along with other new predictions, using a different credit spread measure and a different econometric method.

We measure the quarterly operating cash flow (OCF) as operating income before depreciation (Compustat data item 21) adjusted for working capital accruals (Dechow (1994)).[16] Cash flow volatility is measured as the coefficient of variation in a firm's quarterly operating cash flows over the past six year period:

$$\text{CVCF} = 100 \times \frac{\text{standard deviation of OCF}}{|\text{mean of OCF}|}. \tag{10}$$

[16] Minton and Schrand (1999) argue that debtholders can only claim the firm value after investments. They adjust this operating cash flow number for investment expenditures that are expensed as part of operating income by adding back quarterly research and development and advertising expenses, estimated as the annual research and development or advertising expense from Compustat divided by four. Our results are not qualitatively affected by this adjustment. We do not make such an adjustment here because it would significantly reduce the number of available observations.

A minimum of twelve quarterly observations is required to calculate CVCF. We use a six-year rolling window to calculate CVCF in order to obtain more accurate measures. Similar windows are used by Minton and Schrand (1999) and Molina (2005).

Some firms thrive even during economic downturns. Firm-specific growth rate is another dimension for a firm's total growth rate. Firms with high firm-specific growth rates are easier to survive. Therefore, we should expect that *credit spreads decrease with firm specific growth rate,* an implication of the model in Tang and Yan (2006) who use a cash-flow beta representation. Accordingly, we run the following regression for each firm i using data from the previous six years to obtain the firm-specific growth rate, α^i, for each month:

$$\xi_t^i = \alpha^i + \beta^i \mu_t + \epsilon_t^i, \tag{11}$$

where ξ_t^i is firm i's total cash flow growth rate, μ_t is GDP growth rate, and ϵ_t^i is random noise. Alternatively, we use $\alpha^i + \epsilon_t^i$ to proxy for the firm-specific growth rate and the results are similar with those using α^i alone.

Moreover, a higher systematic growth component should also affect credit spreads. Since economic expansions are much longer than recessions, we should expect that *unconditionally, credit spreads decrease with cash flow beta across firms.* Therefore, we can summarize the discussion above into the following hypothesis:

HYPOTHESIS 2 *In the cross section, credit spreads increase with cash flow volatility, decrease with firm-specific growth rate and with cash flow beta.*

There is also a conditional effect of cash flow beta (β^i) on credit spreads that varies with macroeconomic conditions. Firms with a high beta are more likely to perform well in an up market. In a down market, however, high correlation with the market is not desirable. Campbell and Vuolteenaho (2004) distinguish cash flow beta from discount rate beta and argue that cash flow beta should have a higher price of risk. Therefore, we test the following hypothesis on the interaction between firm characteristics and macroeconomic conditions:

HYPOTHESIS 3 *Credit spreads decrease with the firm-level cash flow beta during economic expansions, while increase with the firm-level cash flow beta during economic downturns.*

In order to test this hypothesis, we need to identify different economic conditions. In our data sample period, there are only three quarters with negative GDP growth: 2001Q3 (−1.41%, annualized), 2001Q1 (−0.49%), 2000Q3 (−0.46%). We regress credit spreads on cash flow betas, obtained from (12), separately for negative growth periods and for positive growth periods and examine whether the signs are different in different economical phases.

Cash flow estimates are summarized in Panel A of Table V. The cross-sectional variations for all three variables are quite significant.[17] Firm-level cash flows are very volatile, consistent with the accounting literature, with the sample average cash-flow volatility around 173%.[18] Cash flow growth is also very sensitive to the economic growth rate. The arithmetic average of firm cash flow beta is 82.68, although the distribution of cash flow betas appears to be quite skewed. Firms with a higher firm specific growth rate have more volatile cash flows and lower cash flow betas, as illustrated in the correlation matrix. However, the correlations are generally low.

B. Methodology

Our dataset is a pooled time-series and cross-section unbalanced panel. Extra care needs to be taken to analyze such a panel dataset. Two types of correlations need to be considered in panel data: (1) Observations from the same issuer cannot be treated as independent of each other, therefore we need to control for the issuer effect; (2) Firms in the aggregate may be affected by the same macroeconomic conditions, therefore we need to control for the time effect. Petersen (2007) provides a detailed analysis on the performance of various approaches for this type of analysis. In this study, we follow Petersen's suggestion and conduct our regression analysis by adjusting for issuer clustering and by controlling for the time effect with monthly time dummies. Because of the use of time dummies, we do not include any other macroeconomic variables in our analysis. The specification we use in our regression analysis is then:

$$CDSSpread_{it} = \beta_0 + \beta_1 \times CVCF_{it} + \beta_2 \times FSG_{it} + \beta_3 CFBeta_{it} + Controls + \epsilon_{it}, \qquad (12)$$

[17]When we calculate cash flow volatility, firm specific growth and cash flow beta, we have limited the minimum number of quarterly observations to be 12 (three years). Hence, the large variation in the cash flow variables is not likely to be due to idiosyncratic reasons. Results are not changed qualitatively even after we remove the top and bottom 10% of the data.

[18]Cash flows, unlike earnings, are hard to smooth by managers.

with issuer-clustered t-statistics for the coefficients, where *CVCF* is the cash flow volatility, *FSG* is the firm-specific growth rate, and *CFBeta* is the cash flow beta. We have also entertained other approaches to obtain robust cross-sectional results.[19] The results obtained from these other approaches are consistent with our issuer clustering-adjusted results. Therefore, we will only report the results based on the issuer-clustered panel regression as described above.

The control variables are from the literature (see, e.g., Zhang, Zhou and Zhu (2005)). We include leverage (measured as the book debt over the sum of book debt and market equity), asset volatility (proxied by the option-implied volatility), and jump risk (proxied by the slope of the implied volatility curve). Panel B of Table V provides summary statistics for the control variables. The average firm has a leverage of 30%, implied volatility of 0.33 and jump risk of 0.27%.

C. Empirical Analysis

We regress monthly average CDS spreads on cash flow variables and other commonly used control variables in a pooled time-series and cross-sectional dataset. Table VI displays the regression results. All regressions include monthly time dummies. The coefficient estimates on those monthly dummies are not shown to save space. Issuer clustering, cross correlation, and heteroskadasticity are adjusted to obtain robust t-statistics.

We find cash flow volatility to be a statistically significant explanatory variable for CDS spreads, consistent with Minton and Schrand (1999) and Molina (2005). However, its economic significance seems limited in the univariate regression (column 1), as a one-standard-deviation move in cash flow volatility only changes credit spreads by about 3 basis points. In a multi-variate regression in column 4, its economic significance triples to about 9 basis points for a one-standard-deviation move. This is consistent with Hypothesis 2. The firm-specific growth rate is only marginally significant, at the 10% level, in the univariate regression (column 2) and becomes insignificant in the multivariate regression (column 4). Note that the firm-specific growth rate embodies the firm-specific risk, so in a well-diversified market, its

[19]We first consider the firm fixed effect rather than issuer clustering. For the second alternative approach, we first calculate the time-series average for each issuer, and then run one cross-sectional regression. This approach suppresses any time-series variations. For the third approach, we run a cross-sectional regression for each month. The average coefficient and its t value are then calculated by aggregating over all the months. This is the standard Fama-MacBeth approach.

pricing impact should be diminished, even though the option nature of bonds may retain some of its influence. Our result is therefore consistent with the notion that systematic, not firm-specific, factors exert a stronger impact on bond pricing, as argued in Gebhardt, Hvidkjaer, and Swaminathan (2005). This notion is further bolstered by the significant impact of cash flow beta on credit spreads, as demonstrated in both column 3 and column 4 of Table VI. Overall, with the exception of the weak evidence on the firm-specific growth rate, the results are confirming the predictions in Hypothesis 2.

Hypothesis 3 is a novel prediction from Tang and Yan (2006). It demonstrates the effect of the interaction between macroeconomic conditions and firm characteristics. In testing this hypothesis, we first directly run separate cross-sectional regressions for periods with negative and positive economic growth and report results in Table VII. We find some supportive evidence for the hypothesis, which comes mainly from positive growth periods (Panel A) when high-beta firms have lower credit spreads, consistent with the unconditional result in Table VI. We also find that firms with higher cash flower beta have higher credit spreads when the economy has a negative growth rate, although the coefficient estimate is not statistically significant due to the paucity of negative growth periods (three quarters) in our data span (Panel B). To test the sign difference of the coefficients across different economic states, we add an interaction term (cash flow beta with negative growth dummy) to the regression model. As reported in Panel C, the interaction term is significant at the 10% level with a t-statistic of 1.84. Therefore, the effect of cash flow beta on credit spreads is indeed different in economic expansions than in recessions. Moreover, we confirm that this pattern persists when we use the NBER classification of economic expansions and recessions (March - November 2001) during our sample period. The signs are different with a t-statistic of 2.63.

In this part of our empirical investigation, we use regression estimates (firm specific growth rate and cash flow beta) as independent variables. This could potentially introduce an error-in-variable problem. Shanken (1992) shows that, in the presence of the error-in-variable problem, the two-pass Fama-MacBeth approach (in estimating risk premium) could result in biased coefficient estimates and incorrect standard errors. If estimation errors within the same cluster are highly correlated, however, our clustering adjustment in the panel data regression may be able to alleviate this concern because the cluster-level correlation is controlled for. At this point, we are not aware of any formal procedure that handles the error-in-variable problem in panel regressions.

VI. Conclusion

In this paper we have empirically examined the effect of market conditions on credit spreads, motivated by the recent development of structural models of credit risk that incorporate macroeconomic conditions. We have tested some of the implications from these models using the CDS datasets for credit spreads and the Moody's KMV's EDF dataset for default probability. We find that, in the time series, CDS spreads are decreasing in GDP growth rate, but increasing in GDP growth volatility. We also document for the first time that credit spreads are significantly lower when investors' sentiment is high and when the systematic jump risk is low.

In the cross section, in addition to confirming the existing evidence on the effect of firm-level cash flow volatility on credit spreads and presenting new results on the role of the firm-specific growth rate, we provide evidence on the importance of the interaction between market conditions and firm-specific characteristics. Specifically, we show that, during economic expansions, firms with high cash flow betas have lower credit spreads, *ceteris paribus*, than firms with low cash flow betas. This relation reverses during economic recessions.

Our results add to the growing evidence on the effect of market conditions on credit spreads, and provide some quantitative assessment of their economic impact. For instance, we show that one-standard deviation shifts in the macroeconomic variables we examined can cause separate moves in average credit spreads ranging from around 10 basis points to 25 basis points. Moreover, our results also demonstrate the importance of heterogeneous firm characteristics in assessing such macroeconomic effects. While in a portfolio context, these macro-economic variables can account for as much as 57% of the variation in average credit spreads, on the firm level, they only account for about 32%. Firm characteristics affect firm-level credit spreads significantly. In addition to the established roles of leverage ratio, implied volatility and a jump measure, we show that firm-level cash flow volatility can be responsible for 10 to 30 basis points in the cross-sectional variation of credit spreads, *ceteris paribus*. Similar magnitudes may be attributable to the impact of cash flow beta in the cross section.

Our study represents one of the first explorations into the interaction of market risk and credit risk, illustrating one of the ways this interaction can transpire in the credit market. Our results also lend support to the cash flow beta representation in Tang and Yan (2006), which may potentially facilitate further studies of credit risk in a portfolio context and enable the development of better risk management tools for banks and corporations. This could be a fruitful venue for future research.

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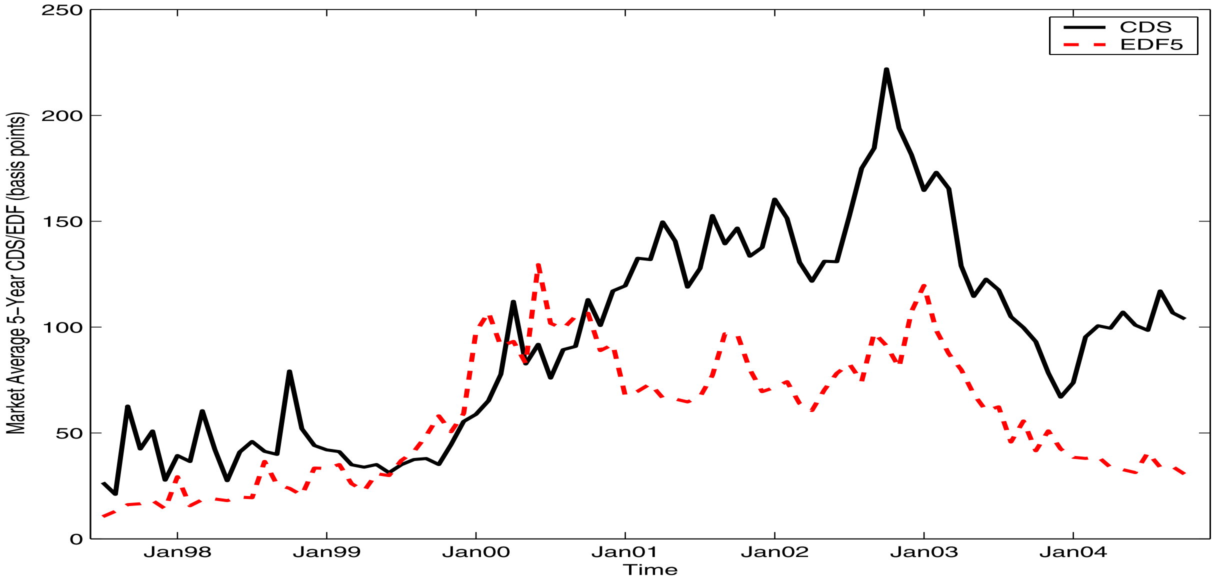

Figure 1. Market average 5-year CDS spreads and 5-year EDFs.

The CDS sample includes only U.S. dollar denominated contracts for U.S. corporations with reference issues being senior unsecured bonds from two CDS brokers: CreditTrade for a period from June 1997 to March 2006 and GFI for a period from January 2002 to November 2006. Intraday quotes are aggregated to obtain monthly average. EDF data are from Moody's KMV for a period from January 1996 to October 2004 for North America non-financial firms. Plotted are monthly averages for the overlapping period from July 1997 to October 2004. Both series are denominated in basis points.

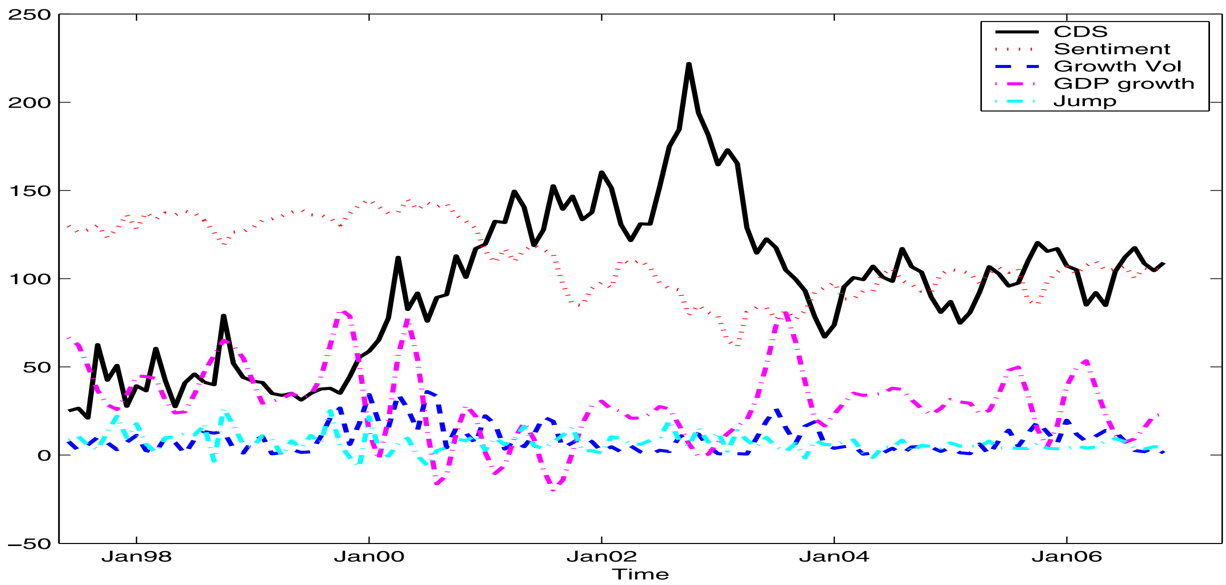

Figure 2. CDS and Macroeconomic Variables.

This figure plots the market monthly average 5-year CDS spreads and the monthly time series of four macroeconomic variables: real GDP growth rate, GDP growth volatility estimated as the unexpected growth rate, investor sentiment proxied by Conference Board Consumer Confidence Index, and jump risk proxied by S&P 500 index option implied volatility slope. GDP growth rate is interpolated from quarterly observations to monthly observations. GDP growth and growth volatility are enlarged by 1000. Jump is enlarged by 10000. The CDS sample includes only U.S. dollar denominated contracts for U.S. corporations with reference issues being senior unsecured bonds. The time period spans from July 1997 to November 2006.

Table I
CDS Data Summary Statistics

This table reports pooled time-series and cross-sectional year-by-year summary statistics of monthly average CDS prices in basis points across credit ratings. The CDS sample includes only U.S. dollar denominated contracts for U.S. corporations with reference issues being senior unsecured bonds, from two CDS brokers: CreditTrade from June 1997 to March 2006 and GFI from January 2002 to November 2006. Intraday quotes are aggregated to obtain monthly average. The entire sample covers the period from July 1997 to November 2006.

		Rating Groups						
Year		AAA	AA	A	BBB	BB	B	NR
1997	*N*	4	6	20	13	5	1	–
	Mean	23.50	24.00	40.17	37.50	71.00	120.00	–
	Stdev	10.79	18.53	41.68	11.69	38.79	–	–
1998	*N*	6	39	119	49	11	–	6
	Mean	38.44	38.35	33.84	54.52	73.41	–	44.11
	Stdev	25.63	32.56	18.66	40.75	47.03	–	14.89
1999	*N*	9	73	238	139	12	–	17
	Mean	38.95	30.15	34.64	70.99	59.82	–	49.08
	Stdev	23.54	15.67	17.30	44.79	18.06	–	28.06
2000	*N*	15	83	326	377	56	15	14
	Mean	57.27	42.26	55.28	130.60	220.07	388.27	166.59
	Stdev	31.13	30.25	38.98	109.80	125.95	125.36	171.75
2001	*N*	24	139	523	625	116	28	16
	Mean	42.68	53.78	84.42	172.40	376.51	596.90	216.47
	Stdev	27.47	37.61	49.93	106.72	151.04	243.97	151.63
2002	*N*	32	94	778	1100	156	56	1634
	Mean	52.00	47.10	91.45	197.59	499.50	557.08	158.15
	Stdev	33.91	25.23	74.16	155.39	229.13	200.89	165.87
2003	*N*	35	51	517	916	247	107	2290
	Mean	35.57	24.90	49.94	137.52	321.06	552.75	102.18
	Stdev	38.55	10.25	36.61	108.00	183.19	282.83	122.92
2004	*N*	26	32	313	581	269	152	3084
	Mean	20.51	26.77	36.06	87.14	163.71	329.08	84.80
	Stdev	9.91	9.76	17.32	58.87	80.52	183.48	90.79
2005	*N*	0	6	287	386	234	171	3890
	Mean		16.29	33.45	89.58	253.91	284.15	88.66
	Stdev		1.60	16.56	100.30	207.58	158.21	105.32
2006	*N*	0	17	150	115	67	54	4258
	Mean		10.87	26.39	79.14	327.00	318.08	108.93
	Stdev		2.84	15.58	69.53	257.17	213.55	133.16

Table II
Descriptive Statistics for Macroeconomic Variables

This table presents descriptive statistics of the four monthly macroeconomic series: real GDP growth rate, GDP growth volatility estimated as the unexpected growth rate, investor sentiment proxied by Conference Board Consumer Confidence Index, and jump risk proxied by S&P 500 index option implied volatility slope. GDP growth rate is interpolated from quarterly observations to monthly observations. The time period spans from July 1997 to November 2006.

						Correlation		
Variable	Obs	Mean	Std.	Min	Max	GDP	GDP Vol	Sentiment
GDP Growth	106	3.21%	2.24%	-1.98%	8.28%	1.000		
GDP Vol	106	0.97%	0.84%	0.04%	3.60%	0.096	1.000	
Sentiment	106	113.06	21.15	61.42	144.71	0.146	0.256	1.000
Jump ($\times 10^4$)	106	7.69	5.73	-6.72	26.42	-0.022	-0.056	0.012

Table III
Macroeconomic Conditions and Credit Spreads

This table reports the regression results of credit spreads on macroeconomic variables. The dependent variable is the 5-year monthly average CDS spreads in basis points. The CDS sample includes only U.S. dollar denominated contracts for U.S. corporations with reference issues being senior unsecured bonds. The reported results are for the time period spanning from January 1999 to November 2006. The independent variables for Panel A are the four monthly macroeconomic series: real GDP growth rate, GDP growth volatility estimated as the unexpected growth rate, investor sentiment proxied by Conference Board Consumer Confidence Index, and jump risk proxied by S&P 500 index option implied volatility slope. GDP growth rate is interpolated from quarterly observations to monthly observations. In Panel B, GDP is replaced by Industrial Production, observed at monthly frequency. For the *Average* regression, market average CDS spread is the dependent variable. The *firm-by-firm* regression regresses firm CDS spreads on macroeconomic variables then coefficients are averaged across all issuers. Standard errors were adjusted by the number of issuers. In the *Residuals* regression, firm CDS spreads are first regressed in a panel regression with monthly time dummies. The coefficient estimates for the time dummies are then regressed on macro variables. First order autocorrelation is corrected for the *Average* and *Residuals* specifications.

	Average		Firm-by-firm		Residuals	
	Coef	t-stat	Coef	t-stat	Coef	t-stat
	Panel A: GDP As Macroeconomic Proxy					
Intercept	244.43	15.85	234.67	12.29	129.68	8.57
GDP Growth	-700.61	-5.45	-562.72	-8.20	-655.44	-5.21
Growth Volatility	555.62	1.97	158.65	1.81	701.52	2.14
Sentiment	-1.22	-8.65	-1.39	-8.57	-1.16	-8.42
Jump ($\times 10^4$)	0.79	1.45	3.23	11.31	0.78	1.45
N	95		284		94	
R^2	0.572		0.321		0.555	
	Panel B: Industrial Production (IP) As Macroeconomic Proxy					
Intercept	224.65	12.80	258.73	12.10	81.54	4.58
IP Growth	-130.41	-2.48	-100.84	-6.01	-135.71	-2.53
Growth Volatility	-15.65	-0.18	-78.17	-1.86	-8.69	-0.10
Sentiment	-1.14	-7.68	-1.58	-9.19	-1.06	-7.07
Jump ($\times 10^4$)	1.02	1.66	2.08	3.55	0.87	1.40
N	95		284		94	
R^2	0.463		0.242		0.430	

Table IV
Macroeconomic Conditions and Default Probabilities

This table reports the regression results of default probabilities on macroeconomic variables. The dependent variables are the 5-year (Panel A) and 1-year (Panel B) monthly Expected Default Frequency (EDF) from Moody's KMV. The reported results are for the time period spanning from January 1996 to October 2004. The independent variables are the four macroeconomic variables measured at the monthly interval: real GDP growth rate, GDP growth volatility estimated as the unexpected growth rate, investor sentiment proxied by Conference Board Consumer Confidence Index, and jump risk proxied by S&P 500 index options' implied volatility slope. GDP growth rate is interpolated from quarterly observations to monthly observations. For the *Average* regression, market average EDF is the dependent variable. The *firm-by-firm* regression regresses firm EDFs on macroeconomic variables then coefficients are averaged across all issuers. Standard errors were adjusted by the number of issuers. In the *Residuals* regression, firm EDFs are first regressed in a panel regression with monthly time dummies. The coefficient estimates for the time dummies are then regressed on macro variables. First order autocorrelation is corrected for the *Average* and *Residuals* specifications.

	Average		Firm-by-firm		Residuals	
	Coef	t-stat	Coef	t-stat	Coef	t-stat
			Panel A: 5-Year EDF			
Intercept	3.94	12.85	4.14	34.85	1.51	4.89
GDP Growth	-13.86	-5.64	-13.99	-34.68	-13.88	-5.66
Growth Volatility	12.66	1.87	15.36	18.80	12.38	1.83
Sentiment ($\times 10^2$)	-0.69	-2.55	-0.90	-10.13	-0.71	-2.64
Jump	20.46	1.21	20.15	2.44	16.11	1.17
N	106		6423		105	
R^2	0.300		0.333		0.305	
			Panel B: 1-Year EDF			
Intercept	3.91	12.73	4.08	29.81	1.08	3.50
GDP Growth	-12.83	-5.20	-14.70	-31.27	-12.86	-5.24
Growth Volatility	12.50	1.84	19.03	19.16	12.18	1.80
Sentiment ($\times 10^2$)	-0.42	-1.54	-0.63	-6.06	-0.44	-1.65
Jump	50.17	1.53	74.30	7.34	45.27	1.48
N	106		6035		105	
R^2	0.248		0.323		0.253	

Table V
Descriptive Statistics of Firm Characteristics

This table summarizes select characteristics of our sample firms. Panel A report cash flow estimates. *CVCF* is the coefficient of variation in quarterly operating cash flow, a measure of cash flow volatility as the standard deviation of past six year cash flow over its absolute mean, in percentage. *Firm Growth* is firm specific growth rate as the growth rate not related to GDP growth rate. *CF Beta* is cash flow beta measured as firm growth sensitivity to GDP growth. At least twelve data points are required to calculate the cash flow estimates. Panel B describes the control variables for our multivariate regressions: *Leverage* measured as the book value of debt over the sum of book value of debt and market value of equity, *IV* as the option implied volatility, and *Jump* as the slope of option implied volatility curve. Data cover the period from July 1997 to November 2006.

						Correlation	
Variable	Obs	Mean	Std.	Min	Max	(1)	(2)
			Panel A: Cash Flow Data				
CVCF (1)	20105	173.70	1912.09	1.41	168654.60	1.000	
Firm Growth (2)	15894	-1.15	43.31	-2507.20	537.68	-0.002	1.000
Cash Flow Beta	17600	82.68	1598.29	-8924.99	54788.09	0.010	-0.091
			Panel B: Control Variables				
Leverage (1)	20701	0.30	0.22	0.00	1.00	1.000	
IV (2)	20444	0.33	0.14	0.02	2.08	0.188	1.000
Jump ($\times 10^2$)	20444	0.27	1.02	-24.35	16.54	0.115	0.014

Table VI
Credit Spreads and Cash Flow Characteristics

The table reports regression results for the effects of cash flow variables on credit spreads. The dependent variable is the 5-year monthly average CDS spreads in basis points. The CDS sample includes only U.S. dollar denominated contracts for U.S. corporations with reference issues being senior unsecured bonds and spans from July 1997 to November 2006. The independent variables are: *CVCF* is the coefficient of variation in quarterly operating cash flow, a measure of cash flow volatility as the standard deviation of past six year cash flow over its absolute mean, in percentage; *FSG* is firm specific growth rate as the growth rate not related to GDP growth rate; *CF Beta* is cash flow beta measured as firm growth sensitivity to GDP growth; (At least twelve data points are required to calculate the cash flow estimates.) *Leverage* measured as the book value of debt over the sum of book value of debt and market value of equity, *IV* as the option implied volatility, and *Jump* as the slope of option implied volatility curve. All regressions include monthly time dummies (not shown). Issuer-clustering, cross-correlation, and heteroskedacity are adjusted to obtain robust t-statistics.

	(1)		(2)		(3)		(4)	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Intercept	92.92	10.58	98.03	9.32	96.68	9.90	-141.29	-9.19
CVCF ($\times 10^2$)	0.15	2.05					0.47	1.88
FSG ($\times 10^2$)			-1.41	-1.67			-1.23	-1.37
CF Beta ($\times 10^2$)					-0.25	-2.15	-0.12	-1.99
Leverage							147.54	4.42
IV							694.82	14.05
Jump							1060.10	5.35
N	18389		14527		16094		12629	
Clusters	564		470		635		418	
R^2	0.069		0.060		0.064		0.557	

Table VII
Credit Spreads and Cashflow Beta in Different Economic States

This table reports the results of the regression in Table VI over two subsamples: negative GDP growth periods (Panel A) covering 2000Q3, 2001Q1, and 2001Q3, and positive growth periods (Panel B) including the entire periods from July 1997 to November 2006 except those three negative growth quarters. The dependent variable is the 5-year monthly average CDS spreads in basis points. Only the coefficient estimate for *CF Beta* is reported. Panel C tests the significance of the sign difference on *CF Beta* across GDP growth periods, as well as NBER recession period (March 2001 – November 2001).

GDP growth	Predicted sign	Coef.	t-stat	N	Clusters
		Panel A: Positive Growth			
3.08%	−	-0.13	-2.07	12250	416
		Panel B: Negative Growth			
-0.79%	+	0.04	0.97	379	106

Panel C: Tests of Sign Difference in CF Beta Coefficients

Sample Comparison	t-stat
Positive GDP Growth vs Negative GDP Growth	-1.84
NBER Expansion vs NBER Recession periods	-2.63

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